March 1990

YAKIMA/KLICKITAT PRODUCTION PROJECT PRELIMINARY DESIGN REPORT

Appendix A:
Refined Project Goals
And Harvest Management Plan

DOE/BP-00245-2

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YAKIMA/KLICKITAT PRODUCTION PROJECT PRELIMINARY DESIGN REPORT

APPENDIX A:

REFINED PROJECT GOALS AND HARVEST MANAGEMENT PLAN

by:
Yakima Indian Nation
Washington Department of Wildlife
Washington Department of Fisheries

EXPERIMENTAL DESIGN PLAN

by:
Pacific Northwest Laboratory

GENETIC RISK ASSESSMENT

by:
Washington Department of Fisheries

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March 1990

REPORT TO THE NORTHWEST POWER PLANNING COUNCIL
ON REFINED PROJECT GOALS ANDHARVESTMANAGEMENT PLAN
FOR THE YAKIMA/KLICKITAT PRODUCTION PROJECT

February, 1990

Prepared Jointly By:

Yakima Indian Nation, Fisheries Management Program
State of Washington, Department of Wildlife
State of Washington, Department of Fisheries

OUTLINE OF REPORT TO THE
NORTHWEST POWER PLANNING COUNCIL
ON REFINED PROJECT GOALS AND HARVEST MANAGEMENT PLAN
FOR THE YAKIMA/KLICKITAT PRODUCTION PROJECT

I. INTRODUCTION

A. Project Purpose

The purpose of the project as stated by the Northwest Power Planning Council is "to test the assumption that new artificial production in the Yakima and Klickitat subbasins can be used to increase harvest and enhance natural production while maintaining genetic resources."

In establishing the goals and objectives covered in this report, the managers endorse the adaptive management policy adopted by the Council for the Yakima/Klickitat Production Project. This approach recognizes that achievement of stated objectives is subject to uncertainty and that flexibility with respect to strategies must be accommodated. Failure of a strategy to meet expectations is an acceptable outcome so long as it results in institutionalized learning. Learning is assured through experimentation and a responsive management process.

The purpose of the Yakima/Klickitat Outplanting Facility is to supplement and enhance natural production of salmon and steelhead stocks in these two subbasins. Spawning and rearing habitat will continue to be protected and enhanced as specified in the Yakima and Klickitat Subbasin Plans so that natural production will be maximized. The ultimate goal of the project is to use supplementation fish as an addition to, rather than as a replacement for, natural production.

It should be noted that YKPP programs do not assume or require implementation of the Yakima and Klickitat Subbasin Plans, but are fully compatible with them. Indeed, Yakima and Klickitat subbasin planners have made the YKPP the nucleus of their plans, and have proposed additional measures intended to enhance natural production. These additional measures--which focus primarily on improving adult and juvenile passage, smolt survival and rearing potential--enhance the production potential of all fish spawning naturally, and would therefore increase the effectiveness of the YKPP.

Production of anadromous salmonids is determined by the status and productivity of the stock. Stock status is the dynamic measure of the condition of the stock at any given time relative to its potential. Stock status is determined by the number of adults that escape fisheries, dams and other hazards to return to the subbasin to spawn. The productivity of a stock is defined as its inherent ability. to produce offspring in surplus to replacement needs in the long term. Such surplus production is necessary to offset passage mortality and to support harvest. It is the purpose of this project to test the potential role of supplementation (described below) to increase both stock status (short-term or intermittent role) and productivity (long-term role.)

The intent of the Yakima/Klickitat Production Project is to integrate wild stock protection, hatchery production, experimentation and harvest through a supplementation program of natural and introduced salmon and steelhead stocks in the two Columbia River basins. The intent is to enhance the existing stocks while maintaining their basic character, adaptability, and fitness and to introduce the best adapted stock in cases where the species is no longer present. In order to achieve a successful outplanting program, a set of critical uncertainties must be addressed through an experimental program designed specifically for this purpose. The project managers have identified the following four areas of uncertainty as having highest priority for supplementation research in the Yakima/Klickitat Basins. They concern the effects of different supplementation strategies on: (1) post-release survival of hatchery reared fish, (2) homing and reproductive success of supplemented populations, (3) genetic implications including long-term fitness of supplemented populations, and (4) inter- and intraspecific interactions (including competition and other consequences of habitat constraints.) Some factors affecting these uncertainties will be experimentally manipulated and the results will be monitored and evaluated. Factors not varied experimentally will be subject to quality control and monitoring standards.

The managers believe that hatchery practices (rearing density, diet, general fish culture techniques) are not among the most critical uncertainties and therefore should be managed as experimental constants while employing the best culture methods known. The project managers recognize that quality control, monitoring and effective record keeping are necessary to control nonexperimental variability. The project goals fall into three categories: productivity enhancement, stock status enhancement, and experimental goals. They are discussed further in Section II. The next section discusses further supplementation concepts incorporated in this project.

B. Supplementation Principles

It is a goal of supplementation to sustain artificially enhanced production of salmon and steelhead in a manner that avoids the creation of separate hatchery and natural populations with conflicting harvest to escapement relationships. The goal is to enhance stocks so that they retain the character, adaptability and fitness of the natural ancestry while benefiting from some of the increased productivity expected from artificial incubation and rearing. However, the experimental emphasis of the project reflects the significance of the uncertainties of success associated with implementation of a supplementation program.

Production plans for most stocks in the Yakima and Klickitat Basins incorporate elements of supplementation. Some portion of the returning adults from each stock will be used as hatchery broodstock. Their offspring will be outplanted in the habitat near locations where they will be expected to return and spawn naturally. Broodstock selection methods and percentages will vary between stocks depending on stock status, productivity, genetic considerations, and management emphasis.

The Yakima/Klickitat Production Project includes eight different stocks covering a wide range of supplementation objectives. The extremes of this range are Yakima spring chinook on the one hand and Yakima coho on the other. The emphasis for spring chinook is on natural production with a very significant but lesser contribution to harvest (and run size) from hatchery supplementation. Natural coho production is currently absent in the Yakima Basin and hatchery out-planted fish are expected to provide for most of the production with lesser coincidental contributions from natural production. All stocks have important experimental objectives with system-wide implications. Examples are: the feasibility of introducing a naturally spawning population of coho, reintroduction of sockeye, inter- and intraspecies interactions. Taken together, the experimental opportunities under the Yakima/Klickitat Production Project addresses a number of issues raised by the Northwest Power Planning Council's Supplementation Technical Work Group in its five-year research work plan. Work in the Yakima and Klickitat basins will be closely coordinated with system-wide supplementation research needs through Technical Work Group members representing the Washington Departments of Fisheries and Wildlife, and the Yakima Indian Nation who also serve on the Yakima/Klickitat Production Project's Experimental Design Work Group.

The best available hatchery practices will be used in the production of all the stocks cultured as a part of the Yakima/Klickitat Production Project. Unless otherwise specified in the experimental design, standardized methods will be used in adult collection and holding, spawning, egg incubation, juvenile rearing, and release of salmon and steelhead.

Events and actions will be documented in a standard fashion with sufficient detail to allow evaluation of their possible impacts on survival and behavior of release groups.

Broodstock policies vary by stock. They are designed to address both genetic and disease considerations. Specific procedures for broodstock selection and treatment are detailed in the Project Master Plan. The fraction of the returning naturally produced escapement that may be used for hatchery broodstock is given in the Harvest Management Plan.

Various production methods have evolved as fish culturists have sought to increase survival rates and improve fry/smolt qualities and at the same time reduce costs. The specific method and rearing design will be developed in detail during the design phase of the project and will be subject to refined project objectives and experimental design requirements.

YKPP PRODUCTION SUMMARY TABLE

SPECIES/RACE	RETURN TO YAKIMA, CURRENT 5-YR MEAN	TOTAL RUN SIZE [a] PRE-YKPP PRODUCTION POTENTIAL [b]	POST-YKPP PRODUCTION POTENTIAL [c]	POST-YKPP PRODUCTION POTENTIAL WITH IMPROVED IN-BASIN SMOLT SURVIVAL [d]
YAKIMA RIVER				
Spring Chinook	5,647	9,801	16,466	41,458
Summer Chinook	0	(5,488 [e])	5,982	20,745
Fall Chinook	1,959	18,450	35,666	44,352
coho	0	(0 [f])	14,545	24,933
Steelhead	2,154	7,199	11,950	49,385 [g]
Sockeye	0	(0 [h])	unknown [i]	unknown [i]
KLICKITAT RIVER				
Spring Chinook	2,523 [j]	3,000	20,000	20,000 [k]
Steelhead	2.034 [l]	6,000	12,000	12,000 [k]
TOTALS	14,317	44,450	116,609	212.873

a. Ocean harvest plus run size at mouth of Columbia. Note that ocean harvest is assumed zero for steelhead.
b. Production potential as estimated in Yakima and Klickitat S&basin Plans (see Refined Goals).
c. Production potential as estimated in Yakima and Klickitat S&basin Plans (see Refined Goals).
d. Includes all measures in Yakima S&basin Plan intended to improve in-basin smolt survival: halving losses in the open river <possibly with a squawfish control program), rebuilding Phase-II screens and subordinating power generation (to instream flow) and rebuilding the bypass system at Uapatox diversion on the Naches.
e. Without hatchery it is unlikely that current potential can be realized.
f. Current oceanic and estuarine harvest rates preclude natural coho production in the Yakima.
g. Includes habitat above Roza Dam.
h. Existing data insufficient to model sockeye production.
i. No quantitative objectives have been set for sockeye due to lack of data.
j. Six-year mean based on available data from 1978, 1980, 1981, 1982, 1983 and 1985.
k. In the absence of data to the contrary, survival of natural smolts in the Klickitat is assumed to be nearly optimal already.
l. Six-year mean based on data from 1981-1982. Note that run size was estimated on the basis of total catch and an assumed ratio between catch and run size.

II. PROJECT GOALS

A. Productivity Enhancement Goals

Productivity may be usefully conceptualized as the number of adults produced per spawner. The YKPP proposes to increase production and harvest potential by increasing the productivity--the number of adults produced per spawner--in supplemented populations. Overall productivity will be enhanced by a sustained increase in the juvenile survival rates of that portion of the supplemented population benefitting from artificial incubation and rearing. Thus, because the fraction of spawners selected as broodstock will produce proportionately more smolts than natural spawners, the mean number of smolts produced per spawner in the population as a whole will increase. If smolt-to-adult survival rates are density independent, and if the productivity of natural spawners is unimpaired, more smolts per spawner imply more adults per spawner.

B. Stock Status Enhancement Goals

An overall goal of this project is to improve the status of salmonid stocks in the Yakima and Klickitat subbasins through supplementation. The ultimate goal is to increase stock status to a level permitting an "Optimal Sustained Yield" (OSY) which approaches the classic concept of "Maximum Sustained Yield" (MSY). MSY stock status is achieved when sustainable surplus production (the production in excess of that needed for population replacement) is maximized. Management of OSY generally entails relatively lower exploitation rates and sustainable surplus production than MSY management. Considerations that might dictate OSY management include protection of a weak substock of wide annual variations in productivity.

C. Experimental Goal

The Yakima/Klickitat Production Project is intended to provide new knowledge regarding the application of supplementation techniques to the Yakima and Klickitat subbasins. Supplementation acts to increase natural production through improved juvenile survival and increased production capacity, thus shifting the productivity of a system from its current inherent level upward to a higher potential productivity level. Consequently, the experimental goal of the project is to design and conduct experiments such that critical uncertainties regarding supplementation are resolved with high certainty.

One requirement for successful application of the adaptive management approach is an effective process of learning from experimentation and making new knowledge available to decision makers. The project managers view the development of a coordinated information and data sharing system as a vital part of this process. Coordination with ongoing Columbia Basin-wide efforts to develop such a system is supported by the managers.

The managers have established an Experimental Design Work Group which will develop and annually (or more frequently, as appropriate) update an experimental plan for the project.

III. PROJECT BENEFIT ANALYSIS METHODS

Projected benefits from the Yakima/Klickitat Production Project have been computed for each stock using the System Planning Model (SPM) developed by the NPPC's Monitoring and Evaluation Group (MEG) for use in Subbasin and System Planning. The SPM was developed by MEG for the purpose of projecting progress towards the NPPC's Fish and Wildlife Program goal of doubling runs to the Columbia River (with accounting for prior harvest.) It was used here for consistency with Subbasin and System Planning.

The approach is based on the concept of Sustainable Production Potential (SPP). SPP is the expected long term production of adult equivalents under a maximum sustained harvest policy. The adult equivalency computation includes all prior harvest and is expressed as adults entering the subbasin. Further discussion of the MEG method of analysis can be found in the <u>Salmon and Steelhead Svstem Planninq Documentation</u>, prepared by the Monitoring and Evaluation Group, Northwest Power Planning Council, August, 1989.

The Yakima/Klickitat Production Project is expected to produce benefits in three areas:

1. It will provide new knowledge about supplementation with applicability throughout the Columbia Basin through an extensive experimental program. These long term benefits outside the subbasins are expected to exceed the direct benefits from new production.

2. Successful supplementation and a harvest plan designed toward rebuilding of runs will increase stability of production and assure that natural production is maintained near optimal levels while maintaining the genetic characteristics of the natural runs.

3. The production potential of each stock will be enhanced when supplementation meets or exceeds current observed survival rates. The implications of increased productivity are greater harvest benefits and larger runs, while rebuilding natural production to MSY levels.

The benefit analyses presented for each stock in the sections that follow are based upon a compilation of data and information on stock and habitat characteristics. Documentation of these data sources may be found in the Yakima and Klickitat Subbasin Plans. The results of the analyses are projected numbers of fish produced under a MSY harvest policy. It was assumed for the purpose of the analysis that natural and hatchery reared fish would be subjected to the same harvest rate.

Due to an agreement among the managers that coho will be managed for hatchery production in the mainstem mixed fisheries, the coho production potential computation maximizes the harvestable surplus from the hatchery alone rather than from the combination of natural and hatchery.

As there is a great deal of uncertainty about production parameters, a measure of skepticism about the results of the analysis is appropriate. When interpreting the results, also keep in mind that the relative values (% of baseline) are more reliable than the absolute numbers. Reanalysis of expectation, based on new information from the experimental program, is an important part of the adaptive process of reviewing and redirecting the program on a regular and ongoing basis. This process will be further developed and described in the report on refined experimental goals.

In Section VI, adult production goals are stated which appear feasible within the context of an adaptive management approach. Critical uncertainties regarding the ability to achieve these goals drive the experimental program.

The production numbers given in Section VI take into consideration (in order of importance) the following:

1. The number of test fish (smolts) needed to address critical uncertainties effectively (the statistical standards were described in the YKPP Master Plan.)

2. Judgement concerning the proper balance between hatchery and natural production from a genetic risk perspective. (Note that improved understanding and active management of genetic risk are important objectives of the YKPP monitoring and evaluation program.)

The adult production goals in Section VI indicate the expectations from a successful supplementation program.

IV. GENETICS

A major element of this project is the conservation of those genetic population characteristics that are currently found in the wild and natural salmonid populations of the Yakima and Klickitat River subbasins. The managers are in agreement with the gene conservation policy emphasized by the NPPC. The planned design and operation of the hatchery facilities have been defined to address genetic conservation goals. In addition the Experimental Design Work Group (EDWC), established on behalf of the managers to develop a long-term monitoring and evaluation program, has begun to focus particular planning emphasis on the genetic aspects of the project.

Several hatchery production strategies have been proposed to minimize the potential for adverse genetic impacts on natural populations:

1. Unique substocks within the subbasins will be identified and separately cultured. Broodstock from different segments--i.e., temporally distinct portions--of the spawning run will be collected in proportion to the relative size of the segment in the natural population, and matings will occur only between males and females of the same segment. Substock-specific culture and disease management requirements will be accommodated within basic facility design.

2. All supplementation fish released from outplanting facilities will be marked. All hatchery broodstock will be

randomly collected from progeny of natural spawners (unmarked adults) so that all fish taken for broodstock will have proven their ability to cope with the rigors of the natural environment system for at least one life cycle.

3. A maximum of 10-20% of returning naturally produced adults will be taken for broodstock (see Harvest Management Plan for details), thus maximizing natural production and minimizing any potential genetic risks from the supplementation program.

4. Breeding practices will be defined during pre-facility planning to insure genetic diversity (e.g. minimum population sizes and mating schemes.)

5. Rearing and release protocols will be developed to minimize any potential negative hatchery influences.

6. Control streams will be established that will not be supplemented and will serve as standards by which to measure supplementation success. Some streams also will serve as genetic refuges for important substocks. Thus far Satus Creek and the American River have been designated as genetic refuges in the Yakima subbasin for steelhead and spring chinook, respectively. Once the number and distribution of genetically distinct, wild/natural substocks of salmon and steelhead have been determined, appropriate control streams will be established for each substock. These control systems will be used to gauge the impact of supplementation on specific substocks.

In addition to these basic production strategies, which will continue to be refined in the ongoing facility planning process, EDWG has identified the need to develop experimental design approaches and a genetic evaluation and monitoring program to test the genetic premise of the project. This pre-facility planning effort will entail characterizing salmonid subpopulations through baseline data collection. Such parameters as adult run/spawning time, adult age structure, juvenile life history traits, genetic profiles, and morphometric/meristic traits will be used to characterize and define substocks. Besides identifying the population units which must be accommodated within the hatchery system, this information will define monitoring and evaluation opportunities and constraints that will shape the experimental plan.

A genetics monitoring and evaluation program will be developed to assess the central goal of increasing harvest and enhancing long-term stock productivity without adverse genetic impacts. Specific experimental hypotheses will be defined and experimental approaches to test these hypotheses will be specified. The experimental plan will, for example, include methods for monitoring genetic change and quantifying potential impacts on stock productivity attributable to genetic change.

These various planning efforts are being pursued by EDWG with the assistance of WDF staff geneticists and other experts in the field contracted by the project. Moreover, the Experi-

mental Design Work Group (EDWG), in cooperation with the NPPC's Monitoring and Evaluation Group (MEG), will develop a process for peer review of the program from the perspective of system-wide genetic monitoring needs. As Yakima/Klickitat genetics monitoring programs may serve as a model for the Columbia basin, EDWG and MEG have begun close coordination in the genetics area.

V. HARVEST MANAGEMENT

Objectives and Guidelines

Terminal fisheries in the Yakima and Klickitat rivers are cooperatively managed by the Washington Department of Wildlife, Washington Department of Fisheries and the Yakima Indian Nation. Salmon and steelhead resources in these basins are managed primarily for tribal subsistence use and for recreational opportunity. The harvest management process described below attempts to provide for basic resource protection and the experimental needs of the YKPP while allowing each management entity to regulate and manage its fisheries with consistency.

The harvest management plans are intended to guide the disposition of salmon and steelhead produced within the YKPP facility and in natural habitats. The plans are designed to support the NPPC's policy of rebuilding natural runs through conservative harvest measures that provide for increasing natural escapements.

The general framework of the plans reflects a balancing of competing needs for tributary harvests, natural stock escapements, genetic resource conservation, and hatchery broodstock. The plans encourage rebuilding of natural escapements through restrictions on harvest rates. Relatively conservative harvest rates are imposed at low stock abundance to accelerate rebuilding while permitting moderate harvest opportunities for treaty and nontreaty fishers. The stock rebuilding phase is here defined as the period during which natural escapements are allowed to increase until interim escapement goals are reached. Thereafter, management of tributary fisheries is designed to probe MSY escapement levels.

The harvest plans also incorporate provisions for achieving the experimental goals of the project master plan. The plans reflect a commitment by state and tribal managers to control harvests when necessary to meet hatchery broodstock requirements, subject to the broodstock collection constraints agreed to in the master plan; and to provide natural escapements sufficiently large to permit evaluation of supplementation experiments. The steelhead harvest plans, in particular, demonstrate a willingness by the WDW to modify current steelhead management policy to support supplementation experiments in the Yakima and Klickitat rivers.

Interception of Yakima/Klickitat Production Project Fish in Ocean and Mainstem Fisheries

Fish produced in the Yakima and Klickitat basins contribute to ocean fisheries from Alaska to California as well as to treaty and nontreaty fisheries in the mainstem Columbia River. Coastal and offshore fisheries are under the jurisdiction of the Pacific Salmon Commission and the Pacific Fishery Management Council. Fisheries in the mainstem Columbia River are co-managed by state fish and wildlife agencies and treaty tribes pursuant to harvest sharing guidelines and stock enhancement goals given in the Columbia River Fish Management Plan.

All Yakima and Klickitat stocks are vulnerable to directed or incidental harvests in ocean and in in-river fisheries. Spring and summer chinook may be taken incidentally in the Strait of Juan de Fuca and other coastal fisheries. Harvests of these depressed stocks in the Columbia River are strictly controlled at low levels to promote rebuilding. Steelhead are not harvested in significant numbers in ocean fisheries, and in-river harvest guidelines for summer steelhead are clearly defined in the Columbia River Fish Management Plan. The fall chinook stock planned for the YKPP contributes significantly to Alaskan and Canadian ocean fisheries and supports the major treaty and nontreaty commercial fisheries in the Columbia River. Coho salmon are harvested intensively in ocean and in in-river sport and commercial fisheries.

Specific effects of these preterminal fisheries on YKPP goals and objectives are difficult to assess. International stock rebuilding commitments, "weak stock" management considerations, and trends toward reduced ocean harvests suggest that increases in ocean interceptions above the rates observed in recent years are unlikely. Further, ocean fisheries that are controlled by catch ceilings will produce lower harvest rates on all stocks as stock abundance increases. Effects on YKPP fish will be beneficial, but perhaps not significantly so.

Impacts of in-river fisheries on YKPP fish will depend to some extent on changes in the production of other stocks. Where mixed stocks are managed as aggregates, any significant new production may affect harvest rates on all stocks. Fisheries managed for aggregate escapement goals, as in the Columbia River, will produce higher harvest rates on all stocks as stock abundance increases. Weaker stocks will tend to be harvested at above-optimum rates while stronger stocks may be harvested at below-optimum rates. Since the effects are stock-specific, further comments on mixed-stock fishery issues are given for each stock in the sections that follow.

Tributary Harvest Sharing

A framework for treaty/nontreaty allocation of salmon and steelhead has been formalized only for spring chinook, but the process is equally suited to the other stocks of interest. The Washington Department of Fisheries and the Yakima Indian Nation jointly develop technical proposals for spring chinook fisheries in co-managed tributaries of the Columbia River. As there is no specific language in the Columbia River Fish Management Plan linking the allocation of salmon in mainstem and tributary harvests, the goal of tributary fishery planning is to achieve an equitable sharing of harvestable spring chinook between tribal subsistence and recreational fisheries.

Technical proposals for tributary fisheries are presented to policy representatives of the co-management entities for final negotiation and agreement. A series of policy-level meetings typically are scheduled to arrive at consensus on equitable sharing of spring chinook harvest opportunities. Upon agreement, the WDF and YIN adopt and exchange regulations for their respective fisheries.

The protocol described above will be modified somewhat for allocating steelhead between treaty and nontreaty fisheries. Unlike salmon fisheries, mainstem and tributary harvests of steelhead are specifically linked in the Columbia River Fish Management Plan to the extent that neither treaty nor nontreaty fisheries in the mainstem and tributaries may harvest more than 50 percent of the harvestable number of steelhead from each co-managed tributary. In other words, treaty and nontreaty sharing of steelhead encompasses not only those adults within the tributaries, but also those taken in tribal and recreational fisheries in the mainstem.

Implementation of the Plans

The species-specific harvest plans are intended to be implemented as soon as is practical for each stock. For example, the Yakima River spring chinook harvest presently is managed according to the plan described for that stock. The timing of implementation of the harvest plan for each stock will be determined jointly by the managers.

Management of the terminal fisheries on the basis of harvest rate control obligates the managers to project stock abundances and monitor terminal harvests in real time. The management entities will jointly explore and develop methods to forecast stock returns to the terminal areas. In addition, the managers will jointly develop fishery sampling programs to track the progress of terminal fisheries toward a specified harvest goal.

Species-Specific Plans

A. Yakima River Spring Chinook - Terminal Harvests

The HMP reflects a commitment to the supplementation experiments and to meeting hatchery production goals, while rebuilding natural runs and harvest opportunities. The project master plan stipulates that only 20% of naturally-produced spring chinook adults may be taken for hatchery broodstock as a safe-guard to genetic resources. Consequently, the broodstock goal of 970 adults will be met at runsizes in excess of 6,000 fish. The interim natural escapement goal of 6,000 adults will be achieved with runs of slightly less than 9,000.

Harvest rates for all fisheries will not exceed 20% on runs less than 9,000 chinook or 30% on runs of 9,000 to 12,000 fish and will be fixed by agreement of the parties at runs in excess of 12,000. The harvest rate is fixed on runs up to 12,000 in order to obtain a range of escapements above the interim goal. These data will serve as an empirical basis for identifying MSY escapements.

Effects of Pre-Terminal Fisheries

Yakima River spring chinook are caught in sport and commercial fisheries from Oregon to Alaska. The contribution of Columbia River stocks to all ocean fisheries is not well known, but is thought to amount to less than 10% of any run. Ocean harvest ceilings and weak stock management of ocean fisheries suggest that significant increases or decreases will not occur.

The Columbia River Fish Management Plan filed in October, 1988 in U.S. Federal Court anticipates increased mainstem harvests of spring chinook as the upriver stocks rebuild. The Plan presently limits harvest impacts on underescaped runs to roughly 12% of counts at Bonneville Dam. As runs increase above the aggregate escapement goal, harvest rates will increase on all stocks. Management in the mainstem for an aggregate escapement goal, as the Plan intends, means that stocks of different productivity and status will deliver escapements and surplus harvest to their respective subbasins at different rates.

The increased production of Yakima spring chinook as a result of the YKPP is unlikely to significantly affect mainstem harvest levels. The Yakima component of the aggregate upriver run of spring chinook is about 10% of the total. Accordingly, a 40% increase in the Yakima component would increase the aggregate run by less than 4%.

According to the MSY harvest rates estimated in the benefit analysis, the runs entering the Yakima River should consistently meet escapement and experimental needs, while providing significant additional terminal harvest opportunities for both treaty and nontreaty fishers.

B. Yakima River Summer Steelhead

The Columbia River Fish Management Plan contains language specific to steelhead management which stipulates that treaty and nontreaty harvest sharing will include harvests taken by both parties in the Columbia River as well as in its tributaries. The HMP is, therefore, influenced by sport and commercial fisheries in the mainstem.

Recreational steelhead fisheries in the Yakima River currently are designed to harvest most, if not all, hatchery steelhead while reserving wild/natural fish for spawning. Tribal subsistence dipnet fisheries in the Yakima River are not selective with respect to adipose-clipped steelhead. Although steelhead are not a target species in tribal dipnet fisheries, an incidental steelhead harvest would occur in target fisheries on fall chinook and coho that enter the river coincidentally with summer steelhead.

The harvest goal of the HMP is to provide meaningful terminal sport and tribal fisheries while rebuilding natural escapements. Under the YKPP master plan supplementation goal, adipose-clipped steelhead will spawn naturally to rebuild the natural stock to MSY levels. Accordingly, harvest rates on adipose-clipped steelhead will not exceed 55% in all terminal fisheries during the rebuilding phase. This represents a departure from WDW policy which allows for intensive harvests of clipped hatchery fish.

The HMP reflects a commitment to the supplementation experiments and to meeting hatchery production goals. The hatchery broodstock goal of 240 adults, to be taken from an escapement of 2,400 naturally-produced adults to preserve genetic stock integrity, will be met at run sizes in excess of 2,525 fish. The interim natural escapement goal of 9,000 adults will be achieved at runs of about 10,250.

Terminal harvest rates will be restricted until the interim natural escapement goal is reached. Retention of unclipped fish will not be allowed in the sport fishery and a tribal harvest will be limited to 5% of wild/natural runs below 2,400 fish. For wild/natural runs between 2,525 and 10,250, retention of unclipped steelhead will not be allowed in the sport fishery and the tribal harvest rate will be 10%. Harvest rate on clipped steelhead will not exceed 55% in all terminal fisheries up to the interim natural escapement goal. Induced variation in annual escapements above the interim goal will provide an empirical basis for selection of a MSY escapement goal.

Effects of Pre-Terminal Fisheries

Columbia River summer steelhead do not contribute significantly to ocean fisheries. Sport catch of steelhead is minimal in the ocean and sale of steelhead in nontreaty commercial fisheries is prohibited.

Yakima River steelhead will contribute to treaty commercial and nontreaty recreational fisheries in the mainstem Columbia River. The Columbia River Fish Management Plan stipulates that mainstem fisheries will be regulated on the basis of aggregate escapement goals at Bonneville Dam for the wild/natural components of the runs. It further stipulates that the relative abundance of Group A steelhead, which includes the Yakima stock, be taken into consideration "so that tributary fishing opportunities of the parties are not precluded." Harvest rates on Yakima River steelhead in mainstem fisheries have been about 15% for unclipped fish and 20% for adipose-clipped fish.

According to the MSY harvest rates estimated in the benefit analysis, the runs entering the Yakima River are expected to consistently meet escapement needs, while providing significant additional terminal harvest opportunities for both treaty and nontreaty users.

C. Yakima River Fall Chinook – Terminal Harvests

The HMP reflects a commitment to the supplementation experiments and to meeting hatchery production goals while rebuilding natural runs and harvest opportunities. The agreed-to hatchery broodstock collection constraint of 60% means that the broodstock goal of 1,070 will be met at natural escapements larger than 1,780 from runs in excess of 2,250 fish. The interim natural escapement goal of 10,000 adults will be achieved with runs of 13,800. Terminal harvest rates for all fisheries are 20% on runs less than 13,800 and, by agreement of the parties, at runs in excess of that number.

Effects of Pre-Terminal Fisheries

Yakima River fall chinook are caught in sport and commercial fisheries from Oregon to Alaska. The contribution of Columbia River upriver bright (URB) fall chinook to ocean fisheries is high, particularly in the northern range of their ocean migration. Forty percent or more of each URB run may be harvested in Alaskan and Canadian fisheries. Harvest rates for URB fall chinook in fisheries off the Washington and Oregon coasts are negligible.

Fall chinook produced by the YKPP also will contribute to treaty and nontreaty fisheries in the Columbia River. Harvest rates of 20-25% may be expected in nontreaty fisheries below Bonneville Dam while harvest rates up to 45% in treaty fisheries above Bonneville Dam are possible under harvest sharing agreements in the Columbia River Fish Management Plan.

It is clear that the benefits of increased Yakima River fall chinook production will be distributed among many treaty and nontreaty users throughout the migratory range of these fish. It is also clear that, in order to return fish for hatchery and natural broodstock needs as well as for increased terminal harvest opportunities, the YKPP must succeed in enhancing both stock status and productivity.

D. Yakima River Summer Chinook – Terminal Harvests

A harvest management plan for summer chinook will be developed as production plans for this stock become more certain.

Effects of Pre-Terminal Fisheries

Columbia River summer chinook currently are subjected to stock rebuilding efforts through harvest protection and enhancement. Small numbers are harvested annually in tribal ceremonial and subsistence fisheries. The Columbia River Fish Management Plan specifies that incidental harvest impacts are not to exceed 5% of in-river run size in any treaty or nontreaty fishery. The Plan also provides recommendations for increased summer chinook production in several midColumbia basins.

Significant harvest impacts have been documented for certain in-shore interception fisheries, but summer chinook are generally protected in ocean fisheries by weak stock management guidelines. It is unlikely that ocean harvest rates on Yakima River summer chinook will increase.

E. Yakima River Coho - Terminal Harvests

The HMP incorporates the needs of the experimental program and hatchery production goals, while also providing harvest opportunities. Because the master plan does not contemplate restoring natural runs of coho to the Yakima basin, the harvest plan is designed to emphasize terminal harvests of all coho in excess of hatchery needs. The broodstock collection goal of 2,350 adults will be met regardless of tributary run size by importing surplus coho from other hatcheries in the event that harvest and broodstock needs cannot be met. Terminal fisheries will be managed for 50% harvest rates on runs less than 4,700 and for all harvestable surplus on runs exceeding that number.

Effects of Pre-Terminal Fisheries

Yakima River coho salmon are caught in sport and commercial fisheries off the Pacific coast from California to British Columbia. The coho stock identified for rearing in the YKPP is an early-running race which tends to contribute to fisheries south of the Columbia River. They are generally harvested at higher rates in the ocean than are more northerly-migrating stocks. However, because their timing tends to overlap with that of fall chinook, they escape to some degree the higher in-river harvest rates experienced by the later-arriving, north-migrating stocks.

The management entities have agreed that YKPP coho will be treated as a hatchery stock for the purposes of mixed-stock harvest management. The Columbia River Fish Management Plan does not constrain coho fisheries below Bonneville Dam to allow "pass-through" of upriver coho stocks. It is conceivable that 75-90% of the coho run will be harvested in ocean and in-river fisheries before it enters the Yakima River. Under these circumstances, it is unlikely that natural production of coho in the Yakima basin can be sustained. If, however, the supplementation program meets expectations, harvest opportunities will occur in the Yakima River.

F. Klickitat River Spring Chinook - Terminal Harvests

Current production of spring chinook at WDF's Klickitat Hatchery is about 0.6 million spring chinook and smolts. Long-term production plans in the Columbia River Fish Management Plan call for expanded smolt rearing capacity at this facility. Although not explicitly stated in the YKPP masterplan, the management entities intend that production plans for the Klickitat Hatchery will be integrated with those of the YKPP.

The HMP reflects a commitment to the supplementation experiments and to meeting hatchery production goals while rebuilding natural runs and harvest opportunities. The hatchery broodstock goal of 2,900 adults will be met at run sizes of about 4,150 fish.

Harvest rates for all terminal fisheries will not exceed 30% until the natural escapement goal is met* and will be fixed by agreement of the parties at larger run sizes. A somewhat higher harvest rate reflects the need to provide harvest opportunities to high-priority tribal and recreational spring chinook fisheries on the Klickitat River.

* A natural escapement goal will be agreed upon once better information is available on passage and production potential (by 1992.)

Effects of Pre-Terminal Fisheries

Klickitat River spring chinook are caught in sport and commercial fisheries from Oregon to Alaska. The contribution of Columbia River stocks to all ocean fisheries is not well known but is thought to amount to less than 10% of any run. Ocean harvest ceilings and weak stock management of ocean fisheries suggest that significant increases or decreases will not occur.

The Columbia River Fish Management Plan anticipates increased mainstem harvests of spring chinook as the upriver stocks rebuild. The Plan presently limits harvest impacts on underescaped runs to roughly 12% of counts at Bonneville Dam. As runs increase above the aggregate escapement goal, harvest rates will increase on all stocks. Management in the mainstem for an aggregate escapement goal as the Plan intends, means that stocks of different productivity and status will deliver escapements and surplus harvest to their respective subbasins at different rates.

The increased production of Klickitat spring chinook as a result of the YKPP is unlikely to significantly affect mainstem harvest levels. The Klickitat component of the aggregate upriver run of spring chinook is less than 5% of the total. Accordingly, a 50% increase in the Klickitat component would increase the aggregate run by about 2%.

According to MSY harvest rates estimated in the benefit analysis, runs entering the Klickitat River should consistently meet escapement and experimental needs, while providing significant additional terminal harvest opportunities for both treaty and nontreaty fisheries.

G. Klickitat River Summer Steelhead - Terminal Harvests

The Columbia River Fish Management Plan contains language specific to steelhead management which stipulates that treaty and nontreaty harvest sharing will include harvests taken by both parties in the Columbia River as well as in its tributaries. The HMP is, therefore, influenced by sport and commercial fisheries in the mainstem.

Recreational steelhead fisheries in the Klickitat River currently are designed to harvest most, if not all, hatchery steelhead while reserving wild/natural fish for spawning. Tribal subsistence and commercial dipnet fisheries in the Klickitat River are not selective with respect to adipose-clipped steelhead. Although steelhead are not a target species in tribal dipnet fisheries, an incidental steelhead harvest will occur in target fisheries on fall chinook and coho that enter the river coincidentally with summer steelhead.

The harvest goal of the HMP is to provide meaningful terminal sport and tribal fisheries while rebuilding natural escapements. Under the YKPP master plan supplementation goal, adipose-clipped steelhead will spawn naturally to rebuild the natural stock to MSY levels. Accordingly, harvest rates on adipose-clipped steelhead will not exceed 55% in all terminal fisheries during the rebuilding phase. This represents a departure from WDW policy which allows for intensive harvests of clipped hatchery fish.

The HMP reflects a commitment to the supplementation experiments and to meeting hatchery production goals. The hatchery broodstock goal of 350 adults will be met at natural escapements of 3,500 adults from runs of about 4,100 fish. The interim natural escapement goal of 5,000 adults will be achieved at runs of about 6,250. This interim goal will be reviewed once better information is available about passage and production capacity (by 1992.)

Terminal harvest rates will be restricted until the interim natural escapement goal is reached. Retention of unclipped fish will not be allowed in the sport fishery and the tribal harvest will be limited to 5% of wild/natural runs below 3,000 fish. For wild/natural runs between 3,000 and 6,300, retention of unclipped steelhead will not be allowed in the sport fishery and the tribal harvest rate will not exceed 15%. Terminal harvest rate on clipped steelhead will not exceed 55% in all fisheries up to the interim natural escapement goal. Induced variation in annual escapements above the interim goal will provide an empirical basis for selection of a MSY escapement goal.

Effects of Pre-Terminal Fisheries

Columbia River summer steelhead do not contribute significantly to ocean fisheries. Sport catch of steelhead is minimal in the ocean and sale of steelhead in nontreaty commercial fisheries is prohibited.

Klickitat River steelhead will contribute to treaty commercial and nontreaty recreational fisheries in the main-stem Columbia River. The Columbia River Fish Management Plan stipulates that mainstem fisheries will be regulated on the basis of aggregate escapement goals at Bonneville Dam for the wild/natural components of the runs. It further stipulates that the relative abundance of Group A steelhead, which includes the Klickitat stock, be taken into consideration "so that tributary fishing opportunities of the parties are not precluded." Harvest rates on Klickitat River steelhead in mainstem fisheries are probably less than 10% for unclipped fish and 15% for adipose-clipped fish.

According to the MSY harvest rates estimated in the benefit analysis, the runs entering the Klickitat River are expected to exceed escapement needs, as well as providing significant additional terminal harvest opportunities for both treaty and nontreaty users.

VI. REFINED ADULT PRODUCTION GOALS

A. Yakima River Spring Chinook

The spring chinook supplementation program is expected to generate direct benefits to the community in terms of increased fishing opportunities for nontreaty and treaty fishers. However, the primary goal is to discover whether and how supplementation might successfully be used to enhance spring chinook here and elsewhere in the Columbia Basin.

Supplementation success as displayed in Table 1 (page 44) measures the survival (to returning adult) of outplanted hatchery reared smolts relative to natural smolts. Maximum observed smolt-to-adult hatchery smolts have been about 20% of observed natural smolt survival rates. Thus, the minimum supplementation success is expected to be no less than 20%. Investments in the experimental program are expected to increase supplementation success to about 60 percent.

It should be noted that a 60% figure for maximum expected supplementation success is extremely speculative. It is based on the following. First, the best in-basin smolt survival (from release point to the counting station at Prosser) of acclimated hatchery spring chinook smolts observed in the experimental releases made between 1983 and 1987 was about 60 percent of the wild survival rates estimated in 1988 (see Fast, et. al., 1989.) Second, these same experimental releases so far indicate that the smolt-to-adult survival rates of hatchery and wild fish are comparable when smolts are expressed in terms of <u>the number of fish surviving to Prosser</u>. These observations suggest that some fraction of hatchery smolts are less fit to cope with the rigors of outmigration than wild smolts, but that this fraction, which may be as small as 40% under optimal conditions, is relatively quickly "weeded out" of the population. Existing data indicate that this weeding out can occur over distances short enough to be entirely within the subbasin. Thus, optimal expected rates of hatchery and wild smolts surviving to Prosser have been comparable, and because the best survival of hatchery smolts from upriver release points to Prosser was 60% of the mean rate estimated for wild fish.

It is the goal for spring chinook to increase the adult production potential by about 65-70% from the current level. Explicitly, the goal is to increase both total run (escapement to the Columbia plus prior ocean harvest) and escapement to the Yakima by 65-70%. Because of the expected increase in productivity and terminal harvest rate, MSY terminal harvest will more than double. Benefits also include increased resiliency, i.e., greater ability to recover quickly from the effects of overharvest and excessive dam losses. These production goals are achievable from a hatchery production level of 1.6 million spring chinook smolts if a 61% supplementation success is realized.

The management agencies' commitment to the success of the YKPP is reflected in the agreed-upon harvest schedule.

The harvest management schedule assumes that YKPP broodstock needs are fully met when total runsize (natural plus hatchery) exceeds 6,000 fish.

The projected runsizes to the American River under supplementation require some explanation. Runsizes are shown separately in Table 1 for the American River, an unsupplemented genetic refuge, and the remaining Yakima Basin. As survival of supplementation fish increases, MSY terminal harvest rate also increases, causing a decrease in the expected abundance of the unsupplemented American River stock. This is especially true under existing conditions of in-basin smolt survival. Due to a disproportionate clustering of poorly screened irrigation diversions and reaches of partial dewatering in the Naches system, American River fish suffer 20 to 40 percent higher smolt mortality than upper Yakima fish and are, therefore, relatively more vulnerable to overfishing. Thus, for example, under <u>existing</u> conditions, as supplementation increases from 30% to 60%, the American River run would be reduced from 76% of baseline (434 fish) to 9% (52 fish.) However, it is essential to note that programs are already under way to improve in-basin smolt survival rates (in the American River as well as the entire drainage.) The Council's "Phase II" screening program is expected to result in the rebuilding of all inadequate screening systems in current production areas, and EDWG is currently designing a study to determine the magnitude and location of smolt losses in the open river, with the ultimate intention of developing a program to halve smolt losses. If all screens are brought up to current standards, and if open-river losses are reduced by 50% (perhaps as a result of a predator control program), supplementation would pose no threat to the American River stock. The final row in Table 1 displays just this scenario, and predicts that the production potential of the American River would then increase by 80 percent, even under higher exploitation rates. It should also be noted that improving in-basin smolt survival would more than double the productivity of the fishery as a whole. With varying degrees of emphasis--more for species rearing higher in the system, like steelhead, and less for "low-rearing" species, like fall chinook--this is a pattern that is seen for all species targeted by the YKPP. Improved in-basin smolt survival enhances the effectiveness of the YKPP more than any other single measure.

TABLE 1: YAKIMA RIVER SPRING CHINOOK

Projected MSY spring chinook production in Yakima Subbasin under various YKPP scenarios. Production is expressed as percent of naturalpruductionpotential of existing habitat in terms of adult equivalent.

SCENARIO	SUSTAINABLE PRODUCTION POTENTIAL TOTAL RUN [a]	YAKIMA RETURN YAKIMA STOCK	AMERICAN STOCK	HARVEST (BOTH STOCKS) TERMINAL	TOTAL [b]
BASELINE [c] (Unsupplemented)	100% [d]	100% [e]	100% [f]	100% [g]	100% [h]
YEAR 10 PRODUCTION 20% Suppl. success	121%	123%	104%	118%	119%
30% Suppl. Success	133%	140%	76%	154%	145%
40% Suppl. Success	143%	154%	46%	192%	171%
60% Suppl. Success	168%	186%	9%	274%	229%
100% Suppl. Success	218%	244%	0%	444%	348%
60% Suppl. Success plus improved in-basin smolt survival	423%	452%	181%	769%	624%

a Total run = escapement to Columbia plus prior ocean harvest.

b Total harvest = ocean plus estuary plus Columbia River plus terminal harvests.

c Baseline scenario assumed existing habitat conditions within Yakima Subbasin, and planned passage improvements on the Columbia mainstem. All Supplementation scenarios alsoassumed planned passage improvements on Columbia mainstem, and all supplementation scenarios but the lastassumeexistinghabitatconditions.

d Approximate number of adults: 9,801.

e Approximate number of adults: 4,985.

f Approximate number of adults: 565.

g Approximate number of adults: 1,776.

h Approximate number of adults: 3,029.

B. Yakima Summer Steelhead

The summer steelhead supplementation program is expected to generate direct benefits to the community in terms of increased fishing opportunities for nontreaty and treaty fishers. It will also help to determine whether and how supplementation might successfully be used to enhance summer steelhead here and elsewhere in the Columbia Basin.

Supplementation success as displayed in Table 2 (page 50) measures the survival (to returning adult) of outplanted hatchery-reared smolts relative to natural smolts. Maximum observed smolt-to-adult survival rates for hatchery spring chinook smolts have been about 20% of observed natural smolt survival rates. Preliminary data from the Yakima Subbasin suggest in-basin smolt survival rates for spring chinook and steelhead are roughly comparable (see Fast et. al., 1986.) Thus, as was the case with spring chinook, minimum supplementation success was assumed to be no less than 20 percent. In the absence of data comparable to that available for spring chinook, and because in-basin survival rates are roughly comparable between spring chinook and steelhead, the maximal expected supplementation success for steelhead was set at the 60% figure ascribed to spring chinook.

The goal for summer steelhead is to increase the adult production potential by 65-70% from the current level. Explicitly, the goal is to increase both total run (escapement to the Columbia plus prior ocean harvest) and escapement to the Yakima by 65-70 percent. Because of the expected increase in terminal harvest rate and, especially, productivity (production of smolts per female in the hatchery environment is much greater than the production of age-11 smolts per female in the wild), MSY terminal harvest will more than quintuple. Steel-head production outside Satus Creek is currently substantially below the MSY level. It is an objective of the supplementation program to accelerate the rebuilding of natural spawning populations through seeding of severely underused habitat. (The question of interactions between reintroduced steelhead and existing fish populations [including rainbow trout] is addressed elsewhere: no such effects were considered in this analysis.) Benefits also include increased resiliency, i.e., greater ability to recover quickly from the effects of overharvest and excessive dam losses. These production goals are achievable from a hatchery production level of 400,000 summer steelhead smolts if a 60% supplementation success is realized.

The management agencies' commitment to the success of the YKPP is reflected in the agreed-upon harvest schedule (see page 27.) The harvest management schedule assumes that YKPP broodstock needs are fully met when the wild/natural runsize exceeds 2,400 fish. It should also be noted that the harvest rate on adipose-clipped hatchery fish will not exceed 55% during the stock rebuilding phase. This represents a departure from WDW policy, which allows for intensive harvests of hatchery fish. Harvest of hatchery steelhead during rebuilding is fixed at this relatively conservative level to allow supplementation fish to spawn naturally to rebuild the natural population.

The projected runsizes to Satus Creek under supplementation require some explanation. Runsizes are shown separately in Table 2 for Satus Creek, an unsupplemented genetic refuge, and the remaining Yakima Basin. As survival of supplementation fish increases, MSY terminal harvest rate also increases, causing a decrease in the expected abundance of the unsupplemented Satus Creek substock. However, the inverse relationship between Satus Creek stock status and supplementation success is not so dramatic as it is for the analogous substock of spring chinook (the American River substock.) This is so because, in contrast to American River spring chinook, the Satus Creek substock rears <u>below</u> most known areas of heavy smolt mortality. Moreover, approximately half of the Satus fish smolt at age-I, while almost all upper Yakima/-Naches steelhead smolt at age-11 or age-III; egg-to-smolt survival rates in the Satus system are therefore over 50% higher than in the upper drainage. As a consequence of these factors, MSY stock status in Satus Creek does not fall below 50% of baseline until supplementation success exceeds 60 percent. Moreover, if the previously mentioned projects intended to increase in-basin smolt survival (see spring chinook section) are successfully implemented, MSY stock status of the Satus substock should be over 90% of baseline at 60% supplementation success.

Two final points should be made in connection with the anticipated benefits to steelhead production. The first concerns use of the habitat above Roza Dam, and the second the beneficial impact of ongoing efforts to improve in-basin smolt survival.

Habitat above Roza Dam was excluded from all analyses in Table 2 save the last two scenarios. Exclusion of habitat above Roza Dam may only be reasonable in the short term: half the potential steelhead production areas in the subbasin exist above Roza Dam, the fishway at the dam is now fully functional, and increasing numbers of steelhead spawners have been counted above the dam in the three years since the new fishway was installed. Assuming this voluntary colonization continues, the expected benefits of the YKPP to steelhead production may actually approximate the last scenario, which differs from the "60% supplementation success" scenario only in assuming habitat above Roza will be used. However, it is essential to note that the managers have agreed that no YKPP steelhead will be <u>planted</u> above Roza Dam prior to 1995, except as needed to study steelhead/rainbow interactions. Moreover, any such experimental releases will require review and approval by the managers' policy group.

The last two supplemented scenarios summarized in Table 2 clearly show the anticipated benefits of ongoing efforts to improve survival of outmigrating smolts while still in the subbasin. The only difference between the last two scenarios is that the last reflects improved smolt survival (attributable to screening projects and a 50% reduction in observed losses in the open river) while the other does not. The harvest benefits of the project will be nearly tripled if in-basin smolt survival projects are successful.

Table 2. projected MSY summer steelhead production in Yakima Subbasin under various YKPP scenarios. Production is expressed as percent of naturalpmductionpotential ofexistinghabitatinterm of adult equivalents.

	SUSTAINABLE PRODUCTION POTENTIAL				
		YAKIMA	RETURN	HARVEST (BOTH STOCKS)	
SCENARIO	TOTAL RUN [a]	YAKIMA STOCK	SATUS STOCK	TERMINAL	TOTAL [b]
BASELINE [c] (unsupplemented)	100% [d]	100% [e]	100% [f]	100% [g]	100% [h]
YEAR 10 PRODUCTION					
20% suppl. Success	124%	140%	91%	228%	174%
30% suppl. Success	133%	159%	83%	316%	222%
40% Suppl. success	146%	182%	75%	399%	269%
60% Suppl. Success	166%	226%	52%	569%	362%
100% suppl. success	202%	307%	0.5%	862%	523%
60% Suppl. Success, existing habitat quality, expanded habitat quantity (includes drainage above Roza Dam).	285%	390%	83%	676%	453%
60% Suppl. Success, expanded habitat quantity, improved in-basin smolt survival	686%	995%	93%	1952%	1301%

[a] Total run = escapement to the Columbia plus prior ocean harvest.

[b] Total harvest = ocean plus estuary plus Columbia River plus terminal harvest.

[c] Baseline scenario assumed existing habitat quality, no use of habitat above Roza Dam, and planned passage improvements on the Columbia mainstem. All supplementation scenarios also assumed planned passage, and all but thelasttwo assumed no use of habitat above Roza.

[d] Approximate number of adults: 7,199.

[e] Approximate number of adults: 2,702.

[f] Approximatenmberofadults: 1,406.

[g] Approximate number of adults: 780.

[h] Approximate number of adults: 1,605.

C. Yakima Fall Chinook

The fall chinook supplementation program is expected to generate direct benefits to the community in terms of increased fishing opportunities for nontreaty and treaty fishers. It will also produce indirect benefits in the form of new knowledge of fall chinook supplementation applicable throughout the Columbia Basin.

Supplementation success as displayed in Table 3 (page 54) measures the survival (to returning adult) of outplanted hatchery-reared smolts relative to natural smolts. Two levels of supplementation success were assumed: 60 and 100 percent. These rates are relatively higher than those applied to other species for two reasons. First, cultured, zero-age fall chinook smolts are subjected to less than half the "hatchery exposure time" (˜7 months vs '19 months) of yearling smolts like spring chinook or steelhead, and therefore can be expected to undergo proportionately less maladaptive artificial selection. Second, "natural" Yakima fall chinook populations have already been genetically impacted by hatchery practices, as over one million non-native smolts per year have been released in the system since 1983; the difference in survival between such "natural" smolts and supplementation smolts should therefore be relatively less than for other species. The performance goal of the YKPP fall chinook program is 100% supplementation success--i.e., to achieve a smolt-to-adult survival rate for hatchery fish equivalent to that of the existing population of natural spawners. Minimum expected supplementation success is 60 percent.

The goal is for fall chinook to increase the adult production potential by about 90-95% from the current level. Explicitly, the goal is to increase both total run (escapement to the Columbia plus prior ocean harvest) and escapement to the Yakima by 90-95 percent. Because of the expected increase in productivity and terminal harvest rate, MSY terminal harvest will nearly quintuple. Benefits also include increased resiliency, i.e., greater ability to recover quickly from the effects of overharvest and excessive dam losses. These production goals are achievable from a hatchery production level of 3.6 million fall chinook smolts if 100% supplementation success is realized.

Two additional points should be made regarding the anticipated benefits summarized in Table 3. The first is that MSY terminal harvest can be substantially increased by increasing terminal harvest rates, so long as one is willing to sacrifice a measure of <u>total</u> harvest (to all fisheries). Thus, should the managers decide to manage the Yakima fall chinook fishery for maximum sustained <u>terminal</u> harvest (instead of MSY to all fisheries, as was done in Table 3), the benefits to terminal fishers could be substantially increased. The second point concerns the beneficial impacts of ongoing efforts to improve the survival of outmigrating smolts while still in the subbasin. Maximum sustainable harvests are substantially increased by improved smolt survival, though not so dramatically as for summer steelhead. The reason for the relatively smaller benefit for fall chinook is that fall chinook rear (and will be released) much lower in the system, and therefore must negotiate fewer hazards in their outmigration.

Table 3. Projected MSY fall chinook production in Yakima Subbasin under various YKPP scenarios. Production is expressed as percent of natural production potential of existing habitat in terms of adult equivalents.

SCENARIO	SUSTAINABLE PRODUCTION POTENTIAL: TOTAL RUN [a]	YAKIMA RETURN	TERMINAL HARVEST	TOTAL HARVEST [b]
BASELINE [c] (unsupplemented)	100% [d]	100% [e]	100% [f]	100% [g]
YEAR 10 PRODUCTION				
60% Suppl. Success	150%	150%	260%	155%
100% suppl. success	193%	193%	478%	206%
100% suppl. success plus improved in-basin smolt survival	240%	240%	657%	259%

[a] Total run = escapement to Columbia plus prior ocean harvest.

[b] Total harvest = ocean plus estuary plus Columbia River plus terminal harvests.

[c] Baseline scenario assumed existing habitat conditions within Yakima Subbasin, andplannedpassage improvements on the Columbia mainstem. All supplementation scenarios also assumed planned passage improvements on Columbia mainstem, and all supplementation scenarios but the last assume existing habitat conditions.

[d] Approximate number of adults: 18,480.

[e] Approximate number of adults: 3,300.

[f] Approximate number of adults: 627.

[g] Approximate number of adults: 13,808.

D. Yakima Summer Chinook

The principal purpose of the summer chinook project is to reintroduce the stock to the subbasin. If the project is successful, the benefits to the community in terms of increased fishing opportunities for nontreaty and treaty fishers will be substantial. The project will also produce indirect benefits in the form of new knowledge of summer chinook supplementation applicable throughout the Columbia Basin.

Supplementation success as displayed in Table 4 (page 57) measures the survival (to returning adult) of outplanted hatchery-reared smolts relative to natural smolts. The simulation was, unfortunately, complicated by the fact that summer chinook are extinct in the subbasin. Accordingly, it was necessary to make the following assumptions in estimating potential benefits. Mid-Columbia wild/natural summer chinook smolt as subyearlings, like fall chinook, and migrate to the sea in the late spring, also like (but somewhat later than) fall chinook. Therefore, wild summer chinook were simulated in the System Planning Model by attributing wild fall chinook survival rates to a population distributed in historic summer chinook rearing areas (the lower Naches and middle Yakima.) However, the YKPP proposes to release yearling summer chinook smolts. Therefore, hatchery summer chinook were simulated by attributing hatchery spring chinook survival rates to a population with the historic summer chinook distribution.

Supplementation success was rather arbitrarily set at 60 percent. (As will be seen, however, this arbitrariness has little consequence, because the natural component of a successfully re-established population will dwarf the hatchery component.)

At MSY, the potential total run (escapement to the Columbia plus prior ocean harvest) and escapement to the Yakima of a re-established, unsupplemented summer chinook population is 5,488 and 2,898, respectively. Terminal harvest and total harvest to all fisheries are 1,246 and 2,305. If a hatchery program releasing 156,000 smolts annually with a 60% supplementation success is superimposed on this hypothetical fishery, total run and subbasin escapement increase only nine percent, to 6,006 and 3,172, respectively. Obviously, total surplus production could be increased significantly if more than 156,000 smolts were released per year.

The benefits of improving the survival of outmigrating smolts are truly striking in the case of summer chinook: total run and subbasin escapement are more than tripled, and terminal harvest is quintupled. The magnitude of these enhancements is attributable to the fact that the lower Naches River, the heart of the historic summer chinook rearing area, is more afflicted by hazards to outmigrants than any other portion of the subbasin.

Table 4. Projected MSY summer chinook production in Yakima Subbasin under various YKPP scenarios. Production is expressed as percent of natural production potential of existing habitat in terms of adult equivalents.

SCENARIO	SUSTAINABLE PRODUCTION POTENTIAL: TOTAL RUN [a]	YAKIMA RETURN	TERMINAL HARVEST	TOTAL HARVEST [b]
BASELINE [c] (unsupplemented)	100% [d]	100% [e]	100% [f]	100% [g]
YEAR 10 PRODUCTION				
60% Suppl. Success	109%	109%	112%	111%
60% Suppl. Success plus improved in-bash smolt survival	378%	378%	545%	467%

[a] Total run = escapement to the Columbia plus prior ocean harvest.

[b] Total harvest = ocean plus estuary plus Columbia River plus terminal harvests.

[c] Baselinescenario assumed existing habitat conditions within Yakima Subbasin, and plannedpassage improvements on the Columbia mainstem. All supplementation scenarios also assumed planned passage improvements on Columbia mainstem, and all supplementation scenarios but the last assume existing habitat conditions.

[d] Approximate number of adults: 5,488.

[e] Approximate number of adults: 2,898.

[f] Approximate number of adults: 1,246.

[g] Approximate number of adults: 2,305.

E. Yakima Coho

The Yakima coho supplementation program is expected to generate direct benefits to the community in terms of increased fishing opportunities for nontreaty and treaty fishers. In addition, it will, as a secondary benefit, test the feasibility of re-establishing natural coho populations in middle Columbia watersheds. However, as will be seen, it is very difficult to quantify the benefits of a coho project because of the extreme scarcity of data on mid-Columbia coho.

Coho will be harvested at a rate that will maximize harvest of hatchery fish. The benefit analysis assumes that hatchery broodstock will be collected in the Yakima subbasin. Simulations with the System Planning Model indicate that very few natural spawners will contribute to the harvest of a fishery managed for hatchery returns. Although no fisheries, terminal or preterminal, will be restricted to protect whatever fish may escape various fisheries to spawn naturally, no effort will be made to prevent natural spawning.

The managers have agreed that no coho will be out-planted above Roza Dam prior to 1995. Off-station supplementation in the Naches system shall not exceed the needs of limited feasibility studies. The YKPP Experimental Design Work Group will identify study streams and numbers of test fish needed to study feasibility.

Estimation of the potential benefits of the coho program was complicated by the lack of data for Yakima and mid-Columbia coho populations. Although a maximal (viz., zero-density) egg-to-smolt survival rate for mid-Columbia coho was provided by MEG, other System Planning Model parameters were derived from spring chinook and from observations of the survival of a number of recent releases of hatchery coho smolts made in the Yakima. The initial, species-specific egg-to-smolt survival rate for coho was reduced by juvenile mortality agents by assuming equivalence with the estimated impact on spring chinook. If, for instance, a localized area of heavy deposited sediments was estimated to reduce spring chinook egg-to-smolt survival by 10%, it was assumed to have the same proportionate effect on coho. The cumulative in-basin losses of outmigrating coho smolts were, on the other hand, assumed to be exactly the same as spring chinook. Thus, the hypothetical natural Yakima coho population had a species specific egg-to-smolt survival rate, distribution and carrying capacity, but an in-basin smolt survival rate borrowed wholly from spring chinook. The in-basin survival rate of hatchery coho smolts was assumed to be 86 percent of the natural rate, because the mean survival of three releases of hatchery coho in the Yakima was 86 percent of the estimated wild spring chinook survival rate.

Estimated coho benefits of the YKPP coho project must be displayed differently from the other Yakima species, because there is no baseline population, real or hypothetical, for comparison: the System Planning Model predicts that an unsupplemented natural population will quickly go extinct, even if terminal exploitation is zero. Thus, the data summarized in Table 5 (page 62) is presented directly, in terms of returning adults. The concept of "supplementation success" is also problematic when applied to coho, again because there is no real or hypothetical natural coho population for comparison. The hatchery returns in Table 5 assume smolt-to-adult return rates for hatchery coho will be 86% as large as a population of wild spring chinook, if the spring chinook population had a rearing distribution identical to the coho. In real terms, the returns reflect smolt-to-adult return rates of 0.19 percent at the subbasin level and 0.73 percent at the mouth of the Columbia.

From a release of 2,000,000 smolts, the simulation predicted a total run (escapement to the Columbia plus prior ocean harvest) of 14,545 fish, an escapement to the Yakima of 3,779 fish (six of which are natural), a terminal harvest of 907, and a total harvest to all fisheries of 9,614. Initial goals for the project were considerably higher: specifically, a 2.0 percent smolt-to-adult survival rate, measured in terms of total run, had been targeted. At this rate, a total run of 40,000 fish would be produced, 25,455 more than were predicted by the most recent simulation.

Predictions of the benefits of a supplementation project in the mid-Columbia for coho are probably very imprecise: there simply are not many coho above McNary Dam from which population parameters may be extrapolated. Therefore, at the present time, it is impossible to judge whether smolt-to-adult return rates from the coho project will be closer to 0.7 or 2.0 percent.

Table 5. Projected MSY coho production in Yakima Subbasin under various YKPP scenarios. Production is expressed as adult equivalents.

SCENARIO	SUSTAINABLE PRODUCTION POTENTIAL TOTAL RUN [a]	YAKIMA RETURN	TERMINAL HARVEST	TOTAL HARVEST [b]
BASELINE [c] (unsupplemented)	0	0	0	0
YEAR 10 PRODUCTION				
86% Suppl. success	14,545	3,779	906	9,614
86% Suppl. success plus improved in-basinsmolt survival	24,933	6,478	3,628	18,553

[a] Total run = escapement to the Columbiapluspriorocean harvest.

[b] Total harvest = ocean plus estuary plus Columbia River plus terminal harvests.

[c] Baseline scenario assumed existing habitat conditions within Yakima Subbasin, and planned passage improvements on the Columbia mainstem. All supplementation scenarios also assumed planned passage improvements on Columbia mainstem, and all supplementation scenarios but the last assume existing habitat conditions.

F. Yakima River Sockeye

Pending outcome of ongoing feasibility studies,no sockeye production is included in the Yakima/Klickitat Production Project plan at this time.

The development of analysis of potential benefits from sockeye supplementation is currently under consideration.

G. Klickitat Summer Steelhead

Klickitat steelhead production will be phased in over a period of 10 years. The goal is to increase adult production potential (adult runsize to the mouth of the Columbia at MSY) from an estimated 6,000 to about 12,000 (see Klickitat Subbasin Plan dated May 31, 1989 and the Preliminary Subbasin Analysis Report) and to gain knowledge about steelhead supplementation with applicability elsewhere in the Columbia Basin.

The preliminary assessment of the numbers of smolts required to meet this goal is 260,000. We do not yet have all the information needed to describe the production program in sufficient detail to confidently proceed with final design. Hence, the preliminary nature of the numbers.

Remaining uncertainties about the supplementation opportunities in the basin will be removed once a better understanding is attained of the current and future passage conditions at Castile Falls. The production objectives above assume no production above Castile Falls. More detailed information about potential release sites both above and below Castile Falls is also needed. This information, along with answers to adult and juvenile monitoring feasibility questions, are needed to refine the experimental program.

We expect to complete a set of further refined production goals and a more detailed experimental plan for the Klickitat in time for final design to proceed by April, 1992.

This schedule is not expected to alter the phased completion of a fully integrated YKPP, where the Klickitat components of the project are intended to follow the Yakima components which are currently at a more advanced planning stage.

The harvest management plan projects a 10-15% preterminal (primarily in the mainstem Columbia) harvest rate, leaving significant additional terminal harvest opportunities for both treaty and nontreaty fishers. The HMP reflects a commitment by the managers to the supplementation experiments and to meeting hatchery production goals. The hatchery broodstock goal of 350 adults will be met at natural escapements of 3,500 adults from runs of about 4,100 fish.

H. Klickitat River Spring Chinook

Klickitat spring chinook production will be phased in over a period of 10 years. The goal is to increase adult production potential (adult runsize to the mouth of the Columbia at MSY) from an estimated 3,000 to about 20,000 (see Klickitat Subbasin Plan dated May 31, 1989 and the Preliminary Subbasin Analysis Report) and to provide new knowledge about supplementation with applicability elsewhere in the Columbia Basin as a part of the YKKP experimental Program.

The preliminary assessment of the numbers of smolts required to meet this goal is 3.0 million. Out of the 3.0 million smolts needed, the existing WDF Klickitat facility will produce about 600,000 with the remainder planned for the new facility. We do not yet have all the information needed to describe the production program in sufficient detail to confidently proceed with final design. Hence, the preliminary nature of the numbers.

Remaining uncertainties about the supplementation opportunities in the basin will be removed once a better understanding is attained of the current and future passage conditions at Castile Falls. The production objectives above assume no production above Castile Falls. More detailed information about potential release sites both above and below Castile Falls is also needed. This information along with answers to adult and juvenile monitoring feasibility questions are needed to refine the experimental program.

We expect to complete a set of further refined production goals and a more detailed experimental plan for the Klickitat in time for final design to proceed by April, 1992. This schedule is not expected to alter the phased completion of a fully integrated YKPP, where the Klickitat components of the project are intended to follow the Yakima components which are currently at a more advanced planning stage.

The harvest management plan projects a preterminal harvest rate (in ocean and mainstem fisheries) of about 20%, leaving significant additional terminal harvest opportunities for both treaty and nontreaty fishers. The HMP reflects a commitment by the managers to the supplementation experiments and to meeting hatchery production goals. The combined hatchery broodstock goal of 2,900 adults will be met at runsizes of about 4,150 fish.

EXPERIMENTAL DESIGN PLAN FOR THE YAKIMA/KLICKITAT PRODUCTION PROJECT

Prepared by the

Yakima/Klickitat Production Project
Experimental Design Work Group

March 1990

Prepared for
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EXECUTIVE SUMMARY

This report details the current status of the experimental design plan for supplementation of salmonid populations in the Yakima and Klickitat sub-basins under the Yakima/Klickitat Production Project (YKPP). The central hypothesis is that new artificial production in the Yakima and Klickitat sub-basins can be used to increase harvest and to enhance natural production without adversely affecting genetic resources. This plan was designated as Task 3 by the Northwest Power Planning Council (the Council) in its authorization to Bonneville Power Administration (BPA) to implement predesign work for the project. The YKPP will help to determine what role supplementation should have in rebuilding production in the Columbia Basin. This includes helping to guide investments and to describe and/or determine benefits, constraints, and procedures. The first annual report on YKPP experimental features (EDWG 1988) recognized a necessary evolution in the development of the final pre-implementation experimental design, and of monitoring and evaluations. This report identifies unanswered questions related to the physical and biological resources of the Yakima and Klickitat River subbasins that constrain the experimental design task. It also describes an approach that recognizes predesign uncertainties and hatchery design/implementation needs.

Planning will continue through 1995 for both basins, with annual revisions of the experimental plan. Implicit communication links contained in the planning cycle enhance coordination and guide success of the YKPP Experimental Design Work Group (EDWG) plans. These include regular meetings, external peer-review of products, and dual membership roles on related Technical Work Groups (TWGs). Although implementation of the experimental plan is envisioned in 5-year cycles, review and modifications, based on progress of experimental results, will occur on an annual basis. A review process integrating technical findings and data is planned. This review will provide the mechanism for timely incorporation of experimental findings into the management process. The EDWG will continue to provide technical oversight for experimental plan development, review, and modification.

The basic goal of the YKPP is to enhance stocks of salmon and steelhead through hatchery supplementation, but to not create separate hatchery and natural populations with irreconcilable harvest and escapement needs. Stocks planned for the YKPP include spring, fall, and summer chinook salmon, coho salmon, sockeye salmon, and steelhead trout in the Yakima Basin, and spring chinook salmon and steelhead trout in the Klickitat Basin. Each of the eight stocks has differing supplementation objectives that are described in more detail in this document.

The success of supplementation is founded on the following set of operating assumptions:

1. Hatchery fish will survive and return to the target spawning areas at rates equal to substantial fractions of estimated natural rates.
2. Supplemental populations (both hatchery and naturally-produced fish) will successfully reproduce.
3. Supplemental populations will not suffer significant losses of fitness over the long term.
4. Inter-specific and intra-specific interactions can be managed to avoid unintended effects.

In order to avoid experimental confounds, hatchery practices must be carefully standardized. Therefore, rigid guidelines for hatchery operations will be developed and observed. It should be clearly noted that hatchery practices are not treated as an experimental variable.

The experimental criteria are designed to provide rigorous answers to issues relating to the central hypothesis of the YKPP program. Accordingly, scientifically conceptually sound and statistically valid methods will be employed. Sufficient replicate treatment and control groups will be employed to answer questions with a specified degree of statistical power and significance. Applicability over the entire Columbia Basin is an important element of all experimental designs.

The experimental design is an iterative process using knowledge gained at each step to refine future actions. Available information from the literature and ongoing studies in the Yakima Basin are used to develop the initial program. Pre-facility studies described in the annually-revised working plans will provide information for the second iteration. The third stage of refinement will occur after hatchery-reared fish become available to conduct the first set of structured hypotheses testing. Each iteration of the experimental program design will involve the following basic steps: 1) identification of critical uncertainties, 2) identification of appropriate response variables, and 3) modification of previous uncertainties and hypotheses based upon results of the experimental program.

The central experimental hypothesis of the YKPP will be evaluated against four categories of population response: 1) post-release survival of hatchery fish, 2) reproductive success of supplemented populations, 3) long-term fitness of supplemented populations, and 4) inter-specific and intra-specific interactions. Opportunities and constraints for measurement of each of these criteria are complex and will involve monitoring and evaluation of a wide array of biotic and abiotic factors.

Post-release survival is defined as survival from time of release until adults return and spawn. It is important that post-release survival be high enough that the advantages attributable to artificial incubation and rearing are not offset. It should be borne in mind that the standard against which post-release survival will be assessed is the survival of natural fish.

In-basin survival of smolts, both supplemented and natural, has been identified as a critical uncertainty that is being addressed in pre-facility work. Reproductive success is defined as the number of offspring produced per unit of spawners. The relative reproductive success of hatchery mixed and natural matings is a critical uncertainty.

In the context of the YKPP, a "fit" population is one that maintains its genetic identity and diversity. The maintenance of fitness of supplemented populations over the long term is a critical uncertainty. In order for fitness to be maintained, existing sub-stocks must be identified and appropriate broodstock collection practices must be developed and implemented.

Species interactions consist of the effects supplemented populations have on other species of interest. Measurable components of species interactions include population abundance and distribution, growth rates, carrying capacity, and survival rates. In particular, interaction between supplemented populations of steelhead trout and resident rainbow trout has been identified as a critical uncertainty.

Supplementation objectives, critical uncertainties, and experimental protocols have been developed for each of the stocks to be supplemented under the YKPP. The critical uncertainties are discussed within the context of the four population response categories. Pre-facility information needs and initial post-facility experimental hypotheses are also identified. This information outlines the current status of experimental planning. Current detail on hypotheses relating to critical uncertainties reflect "state-of-progress" for issues dealt with to date. Annual review will result in the elaboration and refinement of the experimental plan.

A monitoring program is being developed to measure response variables identified in the experimental plan. Population responses are expressed in terms of survival by life stage (post-release survival), reproductive success, long-term fitness (genetics monitoring), and interactions effects. Specific experimental response variables that must be measured include: 1) survival of fish from release through outmigration, 2) contribution to major fisheries, 3) adult returns to the sub-basin, and 4) spawning. Additional response variables measuring reproductive success and long-term fitness are being identified. Development of appropriate methods for monitoring these characteristics is a primary goal of the pre-facility experimental program. Response variables for studies of genetic effects of supplementation, intra-specific and inter-specific interactions, and stock assessment must be identified and coordinated within the monitoring program. Sampling rates, locations, schedules, and procedures will be further refined as current baseline data collection studies provide more information and as research needs are further refined.

The YKPP recognizes that coordination with other projects in the Columbia Basin is important. At the present time coordination is occurring by means of EDWG members who participate other TWGs throughout the Columbia Basin. We anticipate that coordination will continue on this level and through other evolving mechanisms.

The outline that follows highlights some of the elements of the experimental plans for individual stocks.

YAKIMA BASIN SPRING CHINOOK

Supplementation Goal

Increase production potential to 65% above current level.

Critical Uncertainties

In-river survival rates for smolts, where mortality occurs, and factors causing mortality.

Strategies for acclimation that optimize survival

Reproductive success of adult returns from hatchery stocks and naturally-produced fish.

Number and distribution of genetically distinct sub-stocks in the basin.

Pre-Facility Needs

Test the effect of different release treatments (i.e. acclimation, conditioning) on survival of smolts.

- Determine homing ability and distribution of returning supplementation adults.

Develop methods for monitoring the reproductive success and long-term fitness of hatchery supplementation fish.

- Determine any adverse genetic effects occurring in both supplementation and naturally-produced fish.

YAKIMA BASIN SUMMER STEELHEAD

Suoolementation Goal

Increase adult production potential in the Yakima River to 65% above current level, while maintaining Satus Creek production at current levels.

Critical Uncertainties

- Effects on genetic variability of rearing all supplementation steelhead for one year.

In-river survival rates for smolts, where mortality occurs, and factors causing mortality.

Optimal size and manner of release for outplanting steelhead.

- The genetic effect of using hatchery-reared native stock to supplement natural production.

- Effects of re-introduction of steelhead stocks into areas with no current production.

Pre-Facility Needs

Determine locations and cause of in-basin smolt mortality.

- Develop and calibrate smolt and adult monitoring capabilities.

Develop methods for monitoring the homing ability and reproductive success of hatchery supplementation fish.

Evaluate the effect of steelhead supplementation on populations of resident trout.

YAKIMA BASIN FALL CHINOOK SALMON

Suoolementation Goal

Increase production to 95% above the current level.

Critical Uncertainties

Effects of different strategies for rearing, acclimation, and release on post-release survival.

Effects of rearing/release site and acclimation time on age-at-return, maturation, and distribution of spawners

Pre-Facilitv Needs

Determine levels, sources, and seasonal/annual variability of smolt mortality during emigration.

Develop culture strategies to maximize post-release survival of fall chinook smolts.

Develop smolt monitoring capabilities near the mouth of the Yakima River.

Develop adult monitoring methodologies to estimate proportions of hatchery returns in lower river spawning areas.

Develop methods to estimate adult escapement and smolt outmigration.

Assess the sensitivity of reproductive success to changes in female reproductive potential needs.

Define genetic and biological characteristics of existing populations.

Develop genetic monitoring and evaluation plans for facility implementation.

YAKIMA BASIN SUMMER CHINOOK SALMON

Supplementation Goal

Successfully reintroduce the stock into the basin.

Critical Uncertainties

Effects of hatchery rearing and release strategies on smolt-to-adult survival.

Effects of adverse temperature, stream flow, and water quality conditions during summer juvenile rearing/emigration, and adult entry.

Pre-Facilitv Needs

Assess the genetic risk of interbreeding with natural spring chinook stocks and recommend hatchery production alternatives to avoid it.

YAKIMA BASIN COHO SALMON

Supplementation Goal

Create an additional fall harvest opportunity within the Yakima Basin maximizing harvest of hatchery fish.

Critical Uncertainties

Factors affecting in-basin survival.

Pre-Facilitv Needs

Determine levels, sources, and variability of in-basin mortality.

YAKIMA BASIN SOCKEYE SALMON

Supolementation Goal

No objectives have been developed, pending results of a feasibility study conducted in Lake Cle Elum.

Critical Uncertainties

Further experimental design planning has been delayed pending development of a supplementation objective.

KLICKITAT BASIN SUMMER STEELHEAD

Supplementation Goal

Achieve a total adult run size of about 12,000 by year 10 of the program.

Critical Uncertainties

Monitoring capabilities measuring post-release survival.

Availability of acclimation sites.

Maintenance of fitness or maximizing long-term production potential.

Potential for interaction between hatchery-produced summer steelhead and both naturally-produced summer and winter steelhead stocks.

Pre-Facilitv Needs

Determine potential for establishing adult passage over Castile Falls.

Assess acclimation options.

Compare genetic and biological characteristics of current natural and hatchery populations of steelhead (including winter run).

Identify and test monitoring options which will meet experimental requirements of the program: .

Reassess current production and evaluation strategies for consistency with stated objectives.

KLICKITAT BASIN SPRING CHINOOK SALMON

Supplementation Goal

Achieve a total adult run size of 20,000 by year 10 of the program.

Critical Uncertainties

Measurement capabilities for estimating post-release survival.

Availability of acclimation sites.

Operation of current hatchery programs in the Klickitat Basin.

Maintenance of fitness or maximizing long-term production potential.

Pre-Facilitv Needs

Assess acclimation options.

Compare genetic and biological characteristics of current natural and hatchery populations of steelhead (including winter-run).

Identify and test monitoring options which will meet experimental requirements of the program.

Reassess current production and evaluation strategies for consistency with stated objectives.

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Several individuals contributed to the development of the experimental design plan:

Members of the Experimental Design Work Group include:

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Rich Lincoln	Washington Department of Fisheries
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John Easterbrooks	Washington Department of Fisheries

GLOSSARY

Acclimation	The process of rearing hatchery-origin juveniles in a semi-natural environment to begin their adaptation to the environment of the stream in which they will eventually be released and are intended to return as adults.
Broodstock	Spawners used to create a brood of hatchery-reared fish.
Critical uncertainty	An uncertainty that significantly affects the choice and scope of actions that best meet stated objectives. Resolution of such uncertainties is critical to effective implementation and operation of supplementation programs.
Electrophoresis	A laboratory process for the separation and observation of proteins (usually enzymes) that can be used as genetic markers.
Fitness	A measure of the long-term reproductive success or productivity of a stock, sub-stock, or population of interest, which is a result of both genetic and environmental influences.
Genetic diversity	Refers to the range and distribution of genetic material present in species organizational units (e.g., individual, population, sub-stock, stock, or species), and exists at various levels of resolution. Connotes between-unit variation. See also genetic variation.
Genetic marker	A phenotypic characteristic (e.g. allozyme, chromosome band, or pigmentation) that can be used to infer the genotype of an organism.

Genetic variation	Refers to the range and distribution of genetic material present in species organizational units as in Genetic Diversity above. Connotes within-unit variation.
Hatchery fish	Refers to fish that have been spawned and reared under artificial conditions for at least a portion of their life cycle.
Natural fish	Fish spawned and reared entirely under natural conditions, regardless of origin (hatchery or natural).
Outplanting	Any release of hatchery-reared fish to a location not identical to the hatchery site.
Population	A group of fish that freely and naturally interbreed. Populations comprising a sub-stock share genetic material through straying of individual members on a regular basis and, less frequently, with populations comprising other sub-stocks.
Population response	A group of responses observed at the population level which, in this document, fall into four areas--post-release survival, reproductive success, long-term fitness, and species interaction.
Reproductive success	The number of offspring produced per unit of spawners.
Reproductive efficiency	The reproductive success of artificially produced fish relative to that of naturally produced fish.
Response variable	Specific measurable variables which have the following properties: close association with population response, reflective and responsive

	to changes in the population measured, ease of measurement, and small measurement error.
Stock	A group of fish managed primarily for harvest purposes. Units are discriminated by a multitude of factors, including genetic and historical management considerations. Stocks may be composed of one or more sub-stocks.
Sub-stock	A group of fish managed primarily as a unit of production. Unit boundaries are influenced largely by genetic considerations and practical production constraints. Sub-stocks are composed of one or more populations.
Supplementation	The use of hatchery fish to initiate and/or augment natural production (i.e. contribute to natural spawning escapement and subsequent recruitment). This hatchery strategy also normally includes objectives for enhancing harvest benefits.
Supplementation success	As used in this report, this term has a restricted and specific definition: the relative hatchery to wild/natural smolt-to-adult return rate in the first generation.
YKPP	Yakima/Klickitat Production Program

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1.0 INTRODUCTION

This report describes progress toward designing experimental features of the Yakima/Klickitat Production Project (YKPP) as directed by the Northwest Power Planning Council (the Council) in its approval to Bonneville Power Administration (BPA) to implement pre-design work for the project (Brusett 1987). The Council identified several tasks to be completed before it would approve implementing final design and construction of production facilities. Task 3 requires that a design for the experimental aspects of the project be completed with the objective of addressing critical uncertainties related.to supplementation.[a]

The following text details current status of the experimental plan and identifies critical uncertainties related to the pre-facility conditions of stocks and habitats in both basins. Pre-facility studies are planned to address these, and the information from them will be used as a basis for further refinement of the experimental plans described here. The experimental plan is founded on project goals and harvest plans agreed to by the fishery managers (YIN et al. 1990) and on critical uncertainties which could impact project success.

This report contains background material on development and implementation of the experimental plan, including an outline of supplementation goals, strategies for supplementation, and a description of hatchery operation standards and assumptions. The current experimental program rationale is discussed, including overall approach, experimental standards, and relationship of hypothesis testing to critical uncertainties. Detailed outlines of supplementation objectives, critical uncertainties, and experimental design are discussed for each of the stocks to be supplemented under the YKPP. Additional information on the monitoring program and facility requirements is also provided.

(a) Supplementation is defined here as the use of hatchery fish to augment natural production (i.e., contribute to natural spawning escapement and subsequent recruitment). This hatchery strategy also normally includes objectives for enhancing harvest benefits.

2.0 PROCESS FOR EXPERIMENTAL PLAN DEVELOPMENT AND IMPLEMENTATION

The purpose of the YKPP as stated by the Council is to test the assumption that new artificial production can be used to increase harvest and enhance natural production while maintaining genetic resources (Brusett 1987). Explicit emphasis is on experimentation and evaluation to achieve this goal. This emphasis on experimental goals provided impetus for the formation of an Experimental Design Work Group (EDWG) in August 1988. This group, which is comprised of fishery scientists from cooperating management entities and other groups, has been meeting biweekly to design experimental, monitoring, and. evaluation programs for the YKPP. Three primary functions of EDWG are to 1) develop experimental plans, 2) communicate experimental results and experimental design to policy level and facility operators, and 3) communicate and coordinate plans and results to external parties (e.g., the Council, the Supplementation Technical Work Group, the Columbia Basin Fish and Wildlife Authority, the System Policy Oversight Committee, etc.).

2.1 PRE-FACILITY DESIGN

The first report on YKPP experimental features (EDWG 1988) recognized a necessary evolution in the development of the final pre-implementation experimental design and of monitoring and evaluation plans. A number of unanswered questions related to the physical and biological resources of the Yakima and Klickitat River basins were identified that constrained the experimental design task. For instance, the basic sub-population structure of naturally reproducing species within the basins has not been defined sufficiently to finalize broodstock collection, rearing, and release strategies for hatcheries or the genetic monitoring approaches. In addition, fish monitoring capabilities need to be developed in both the Klickitat and Yakima River basins. The ability to accurately measure experimental response variables in the two systems will be directly related to unique operational parameters of the monitoring facilities and possibly will be confounded by currently unknown, in-river mortality patterns, particularly during the smolt outmigration period.

These unanswered questions led to development of an experimental design plan (including monitoring and evaluation approaches) that recognized pre-design uncertainties as well as hatchery design/operational needs. Annual drafts of the experimental design plan will be refined and expanded to reflect the evolution of the plan. Available detail will be provided to help direct design of facilities and operating procedures (Figure 2.1). Concurrently, information that is essential to the final (pre-implementation) experimental plan will be identified. The essential information needs will be incorporated into an annual EDWG Pre-facility Working Plan. This plan will guide pre-facility research studies and ensure that study results actively support

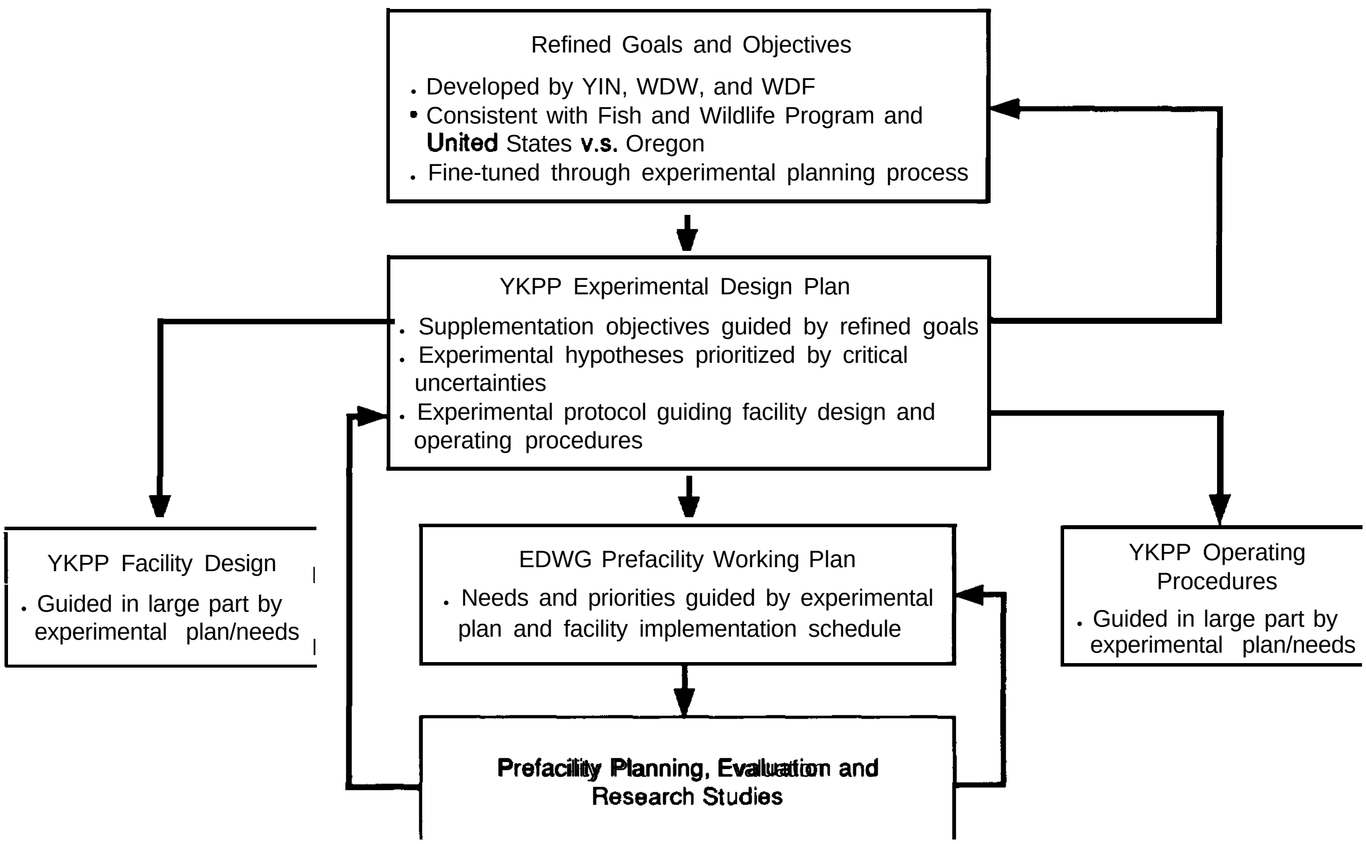

FIGURE 2.1. Yakima/Klickitat Production Project Pre-Facility Experimental Design Planning Process. (Indicates interrelationships with project goal development, annual pre-facility research work planning, facility design, and development of operating procedures.)

completion of experimental plan development. This annual, integrated course of pre-facility planning will continue through 1995 for the Yakima River system, when hatchery implementation is expected. The planning and facility implementation schedule for the Klickitat River system is expected to be delayed at least 2 years behind the Yakima system because needs for planninginformation and monitoring capability development are more extensive (see Chapter 7.0, "Stock-Specific Experimental Features"). Figure 2.2 indicates the schedule for the experimental plan and pre-facility working plan development.

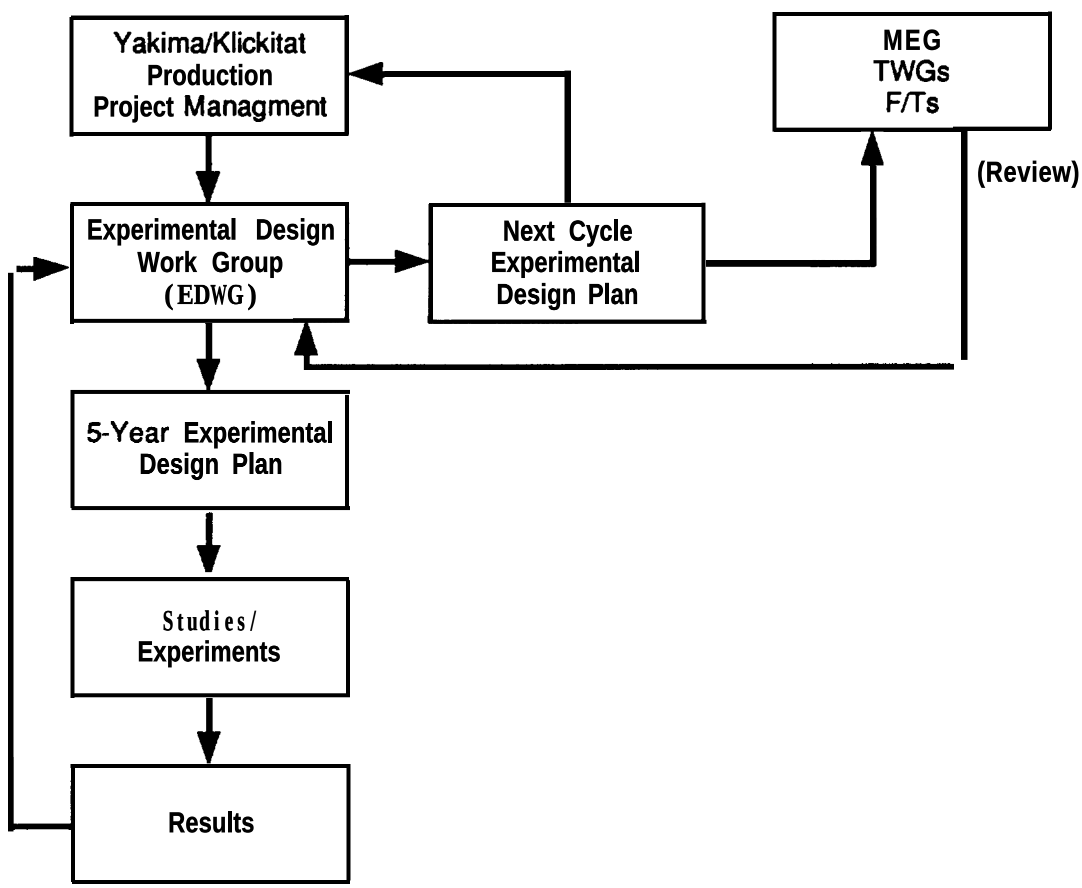

FIGURE 2.2. Post-Implementation Review Process for Incorporating Experimental Results

2.2 COORDINATION AND COMMUNICATION

The iterative planning cycle envisioned above contains implicit communication links that enhance coordination and ultimately guide success of EDWG plans. Monthly meetings of the YKPP Technical Work Group (TWG) include status reports from EDWG. These meetings facilitate communication of experimental direction to facility design and operating procedure planning as displayed in Figure 2.1. Review of EDWG products by TWG members will be solicited along with appropriate external peer review as outlined in EDWG's Terms of Reference. Final drafts of annual planning documents also are submitted to the YKPP policy group comprised of BPA, Washington Department of Fisheries (WDF), Washington Department of Wildlife (WDW), and Yakima Indian Nation (YIN) representatives. EDWG also coordinates with the Council's Monitoring and Evaluation Group (MEG) and the Columbia River Basin Fish and Wildlife Authority's Supplementation Technical Work Group to insure that YKPP research, monitoring, and evaluation activities are consistent with those throughout the basin. Several EDWG members currently hold committee assignments with these basin-wide groups. For example, some EDWG members are also members of the MEG. The MEG is developing system-wide approaches to information sharing (through a Coordinated Information System) and some aspects of monitoring (System Monitoring and Evaluation Program). The MEG may also, in the future, proposal minimal statistical guidelines for studies under the Fish and Wildlife Program. Other individuals or their agencies participate in related activities including FERC relicensing negotiations and resulting programs, the Council's Supplementation Technical Work Group, and the Lower Snake River Compensation Program, and Mitchel Act activities.

Implementation of the YKPP (including EDWG plans) undergo review and coordination in BPA's Implementation Planning Process (IPP). Tasks associated with achieving YKPP goals and objectives will be reviewed by both policy and scientific groups within the IPP. These groups are composed of representatives of the Columbia River Basin Indian Tribes, WDF, WDW, utilities, the Council, and other interested parties.

The YKPP will be a key part of the "global" system-wide process for refining and updating supplementation programs and for addressing other questions of biological uncertainty throughout the Columbia River basin.

These activities are being conducted under other areas of the Fish and Wildlife Program (chiefly the Supplementation Technical Work Group and the Umatilla and Northeast Oregon hatchery programs), within the lower Snake River Compensation Program, the Mitchell Act Program, and under relicensing agreements involving hydroelectric dams on the mainstem Columbia River. These efforts, to the extent that they address basin-wide application of results and use similar approaches, may be viewed as spatial replicates of basin-wide efforts to answer common questions. Maximizing basin-wide benefits of these studies can be realized through conscious coordination and open communication of results and experience gained.

2.3 POST-IMPLEMENTATION REVIEW AND RESPONSE

Once facility construction is complete, implementation of the experimental plan is envisioned in 5-year cycles. The intent of this implementation strategy is to challenge continued improvements in the performance of the YKPP toward meeting its stated objectives. Hypothesis testing will be designed to include measurement of intermediate response variables (e.g., juvenile stage) so results from the first 3 to 4 years of an experimentation cycle (Cycle 1) can be applied to the experimental plan and to production/operating strategies for the next cycle (Cycle 2). Results from measurement parameters of adult and juvenile response variables and longer-term monitoring would be used to adjust intermediate conclusions within Cycle 2 experimental design and to also modify Cycle 3 design.

The technical and policy review process is envisioned to allow timely response towards implementation of results from hypothesis testing. It will build upon annual pre-facility experimental design review processes presently used. Essentially, EDWG will continue to provide technical oversight for plan development, review, and modification on an annual basis. Cyclic modifications to the 5-year plan will be subjected to technical peer and policy review. The management entities will also review and refine YKPP goals and objectives, as appropriate, and provide input to the experimental plan. The finalized 5-year plan will be implemented through a project management structure being formulated in the facility predesign process. The proposed process for postimplementation review and response is depicted in Figure 2.3.

Time Frame	Product	**Related** Activities/Tasks	Group
Jan 1990	**Y/KPP** Experimental Plan (2nd Annual **Verison)**	Technical and Policy Review	EDWG **Y/KPP** TWG and Policy Peers EPA
Apr 1990	Report to N PPC for Final Design and Construction Approval	Review and Discussions at Technical, Public and Policy Level	BPA EDWG **Y/KPP** NPPC Public
Apr 1990	Annual EDWG **Pre-** Facility Working Plan	Identify Priorities, Implementation of Related Studies, Review of Progress, and Feedback of Results to Experimental Plan	EDWG BPA YIN, WDW, WDF Other Entities, Contractors
Jul-Nov 1990	Pre-Facility Studies' Progress Reports	Analyze Results; Make Recommendations	Various Investigations EDWG
Jan 1991	**Y/KPP** Experimental Design Plan (3rd Annual **Review)**	Update Hypotheses, and Experimental Priorities and Pre-Facility Needs	EDWG
Jan-Apr 1991	Experimental Plan Review	Approval, Modifications	EDWG, BPA, YIKPP, Peers
Apr 1991	Annual EDWG **Pre-** Facility Working Plan	Approval, Modifications	EDWG, **BPA, Y/KPP,** Peers
May **1991- Dec** 1994	Repeat Experimental Design and Pre-Facility Work Planning Cydes	Approval, Modifications	EDWG, BPA, **Y/KPP,** Peers
Dec 1995	Initial Five-Year Experimental Design Plan	Related Review and Implementation	EDWG

FIGURE 2.3. Yakima/Klickitat Production Project Pre-Facility Planning Schedule Through Project Implementation

3.0 SUPPLEMENTATION GOALS

Supplementation principles and goals of the YKPP are generally described in the Refined Goals Report (YIN et al. 1990).

3.1 GENERAL YKPP SUPPLEMENTATION GOAL

An overriding goal of the YKPP is to produce more natural salmon and steelhead on a sustained basis without creating separate hatchery and natural populations that have irreconcilable harvest-to-escapement needs. The project's objective is to produce fish with the character, adaptability, and fitness of their natural ancestry while increasing juvenile survival rates through artificial incubation and rearing.

Production plans for most stocks in the Yakima and Klickitat River Basins incorporate elements of supplementation. Some portion of the returning adults from each of those stocks will be used as hatchery broodstock. Their offspring will be outplanted in the habitat near locations where they will be expected to return and spawn naturally. Broodstock collection methods and percentages will vary between stocks depending on stock status, productivity, genetic considerations, and management emphasis (YIN et al. 1990).

3.2 PRODUCTIVITY ENHANCEMENT GOALS

The YKPP's intent is to increase the production (and harvest) potential of targeted stocks by enhancing the number of smolts (and thus adults) produced per spawner. This concept of increased production potential, or productivity, assumes a sustained increase in the adult-to-smolt survival rates from that portion of the supplemented population collected for artificial incubation and rearing. Thus, given this assumption, the fraction of spawners collected for broodstock would produce proportionately more smolts than natural spawners, and the mean number of smolts produced per spawner in the population as a whole would increase. If smolt-to-adult survival rates are density-independent, and if the fitness of natural spawners is unimpaired, more smolts per spawner would equate to more returning adults per spawner. This mechanism envisions the hatchery system as a series of super-productive "pseudo-tributaries" distributed throughout the drainage, producing smolts above levels currently constrained by natural carrying capacity.

A goal closely associated with increased productivity is the goal of improving the status of supplemented stocks in the Yakima and Klickitat Basins. "Stock status" here refers to abundance in the context of carrying capacity and local patterns of density-dependent mortality, and is roughly comparable to the concept of "seeding." The ultimate goal of the YKPP is to increase stock status to a level which approaches the classic concept of "maximum Sustained Yield" (MSY). Maximum Sustained Yield stock status is achieved when sustainable surplus production--the production in excess of what is needed for population replacement--is maximized. Management of the Yakima and Klickitat systems may require somewhat lower exploitation rates and sustainable surplus production than MSY due to considerations such as protection of weak sub-stocks (e.g., if refuge streams discussed below can not sustain at MSY rates).

3.3 SPECIES EMPHASIS

The YKPP includes eight different stocks 1) spring chinook salmon, 2) fall chinook salmon, 3) summer chinook salmon, 4) coho salmon, 5) sockeye salmon, and 6) steelhead trout in the Yakima River basin, and 7) spring chinook salmon and 8) steelhead trout in the Klickitat River basin). The specific supplementation objectives for each stock differ (see Chapter 7.0, "Stock-Specific Experimental Features"). For example, the emphasis for Yakima spring chinook is on natural production with significant but lesser contribution to harvest (and run size) from hatchery supplementation. Coho in the Yakima basin represent the other extreme of specific goals. Because of heavy exploitation in the ocean and the Columbia mainstem, natural coho production is currently negligible in the Yakima Basin; outplanted hatchery fish are therefore expected to provide most of the production when the YKPP comes on line. All stocks have important experimental objectives with system-wide implications.

General production priorities have been established based on a variety of factors. The Yakima portion of the project is moving ahead of the Klickitat as a result of numerous, outstanding pre-facility needs in the latter (see Sections 7.8 and 7.9). In the Yakima spring chinook and summer steelhead have the highest priority due to the emphasis on natural production for these species and thus their importance in answering critical uncertainties of the project. Yakima fall chinook represent the next stock of emphasis given their significant potential for increased natural run sizes and harvest opportunities, followed by Yakima coho. Sockeye have significant potential in the program but this stock's priority will be determined by studies currently underway to assess feasibility of reintroduction. Finally summer chinook have the lowest priority due to habitat conditions and potential for genetic risk (interactions with spring chinook). This stock's implementation in the program will depend on resolution of these problems.

3.4 SUPPLEMENTATION STRATEGIES

The harvest and production goals for targeted stocks represent testable "macro-hypotheses" for the project. These goals are directly derived from a set of observations and assumptions relating to supplementation in the Yakima and Klickitat Basins, almost all of which are explicitly incorporated in the Council's System Planning Model (SPM). A major assumption to be tested through the project is that consistent achievement of production goals requires indefinite supplementation. Although all targeted stocks are currently at abundance levels well below optimum, it is anticipated that supplemented areas will be "fully seeded" (or nearly so) within a single run-cycle (3 to 5 years) after the facilities reach full production. However, harvest and production goals anticipate enhanced production potential, as defined above, which would require that supplementation be continued indefinitely, if successful.

Beyond this central assumption, production goals rest upon a number of more or less tested technical assumptions as well as estimated or assumed population parameters (e.g., carrying capacity, egg-to-smolt survival, etc.). Many of these assumptions are implicit in the structure of the Council's SPM, including the notion of density-dependent, fry-to-smolt survival as a function of habitat quality and quantity (not necessarily the Beverton-Holt survival function used in SPM). Production goals also reflect a number of agreements and expectations regarding harvest and mainstem passage (see the YKPP Refined

Goals Report for a discussion of harvest agreements). A set of general operating assumptions has been adopted on the basis of current knowledge. For example, it was assumed that "state-of-the-art" culture practices (see Chapter 4.0, "Hatchery Operation Standards and Assumptions") will produce hatchery products equal to or exceeding the average quality observed in other hatcheries (Senn et al. 1984).

Under the YKPP, the natural spawning population will be supplemented by returning adults from hatchery-reared fish (Figure 3.1). Yakima and Klickitat spring chinook span the extremes of supplementation strategies. In the Yakima River, a much smaller proportion of the natural spawning escapement will

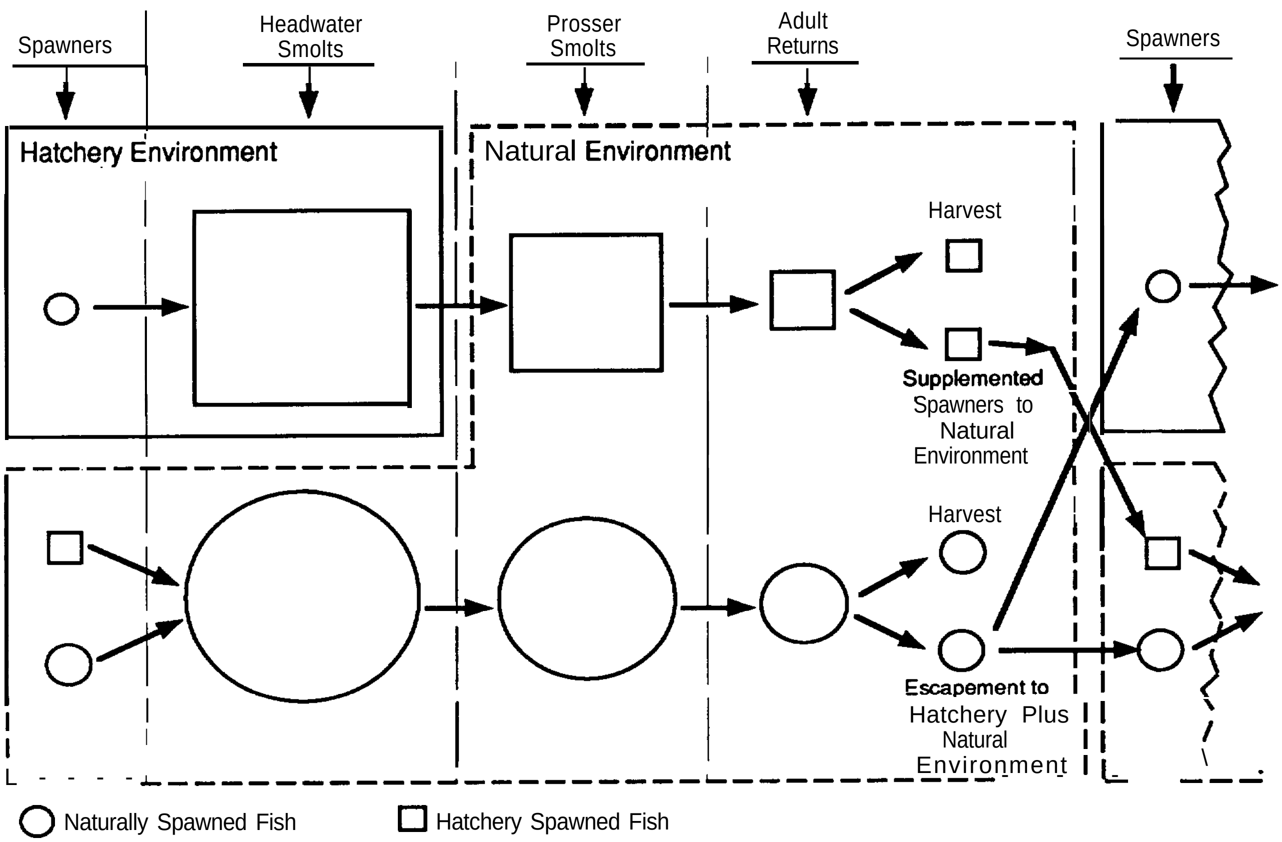

FIGURE 3.1. Conceptual Scenario for Supplementation of Natural Populations in the Yakima Basin. (Illustrates the contributions of hatchery and naturally reared fish to harvest and sustained productions.)

consist of adult returns from hatchery-reared fish than in the Klickitat, where almost all of the natural spawning escapement will be provided by hatchery-reared fish.

In order to achieve supplementation success, it is necessary that: 1) hatchery fish survive and return to the target spawning area, 2) the supplemented population (mixture of hatchery and natural origin fish) reproduce successfully, 3) fitness of the supplemented population be sustained in the long term, and 4) the effects on other populations and species be understood and considered in the management process.

The YKPP strategy is to acclimate and release hatchery-reared fish as smolts in or near desired spawning areas in order to increase the probability of survival and return to a particular area. A smolt release strategy, as noted in the Five Year Research Work Plan of the CBFWA's Supplementation Technical Work Group (STWG 1988), is expected to minimize interactions between juveniles of hatchery and natural populations, while acclimated off-site release is intended to achieve the desired distribution of spawners (including minimizing straying outside of target spawning areas). Juvenile densities during natural rearing are expected to approach those where density dependent mortality associated with competition for food and space comes into operation. Figure 3.2 shows the relationship between expected natural production and carrying capacity. This relationship suggests that interactions between natural fish and hatchery releases are reduced by rearing hatchery fish to the smolt stage, when they may be expected to migrate from the system immediately (see Figure 3.3). Residualism can be a potential interaction concern with smolt releases, particularly steelhead, but the project's intent is to develop a sufficient understanding of hatchery steelhead smolt behavior in the sub-basins in order to minimize potential residualism. Thus, under the YKPP, spawning is the first point in the life cycle when hatchery-reared fish are intended to interact with the natural population.

An attempt to "fit" the offspring of hatchery-reared spawners to the available habitat was made in the manner in which acclimation ponds were sited. Specifically, all tributaries or mainstem reaches receiving an

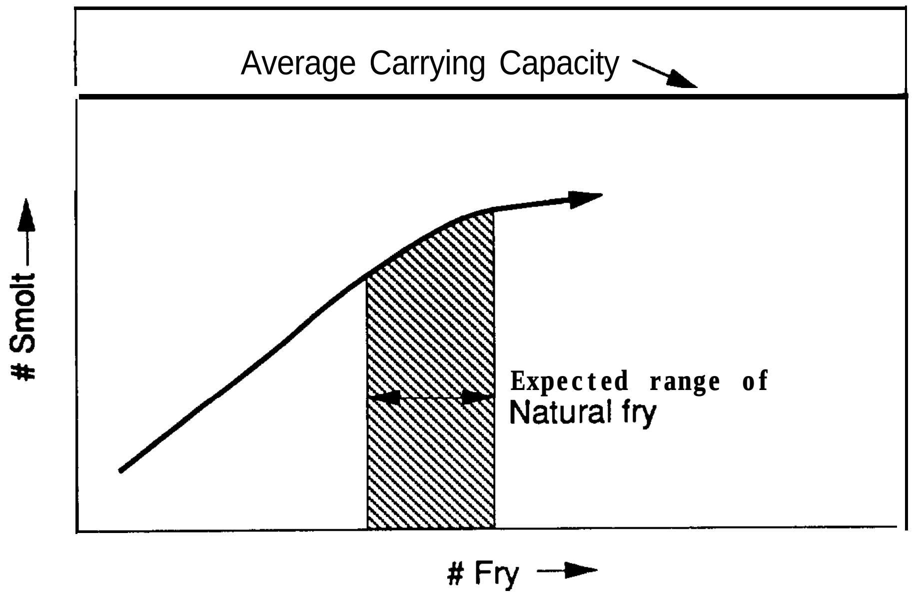

FIGURE 3.2. Conceptual Relationship Between Juvenile Density and Carrying Capacity. (Once the YKPP is in production, the abundance of natural fry is expected to reach levels where density dependent survival is a significant factor.)

acclimation pond will be required to have adequate spawning habitat and a carrying capacity (expressed as smolts) of at least three times the number of smolts allocated to an acclimation pond (75,000 spring chinook and 25,000 to 33,000 steelhead).

The smolt strategies described above apply to a scenario, as expected for the YKPP, where supplemented streams are moderately to well seeded (relative to juvenile carrying capacity). However, other scenarios may exist where supplementation of pre-smolts may be biologically, experimentally, and economically sound. For example, it may be advantageous to use pre-smolts when natural juvenile rearing densities are expected to remain relatively low, compatible hatchery broodstock is readily available, and the cost of improved egg-to-smolt survival through hatchery rearing can not be accommodated. Such a situation could arise in a productive system with severe and intractable passage problems downstream. In such a situation the competitive interactions with pre-existing populations may not be a concern (low expected returns) depending on population status and genetic concerns. Release of pre-smolts

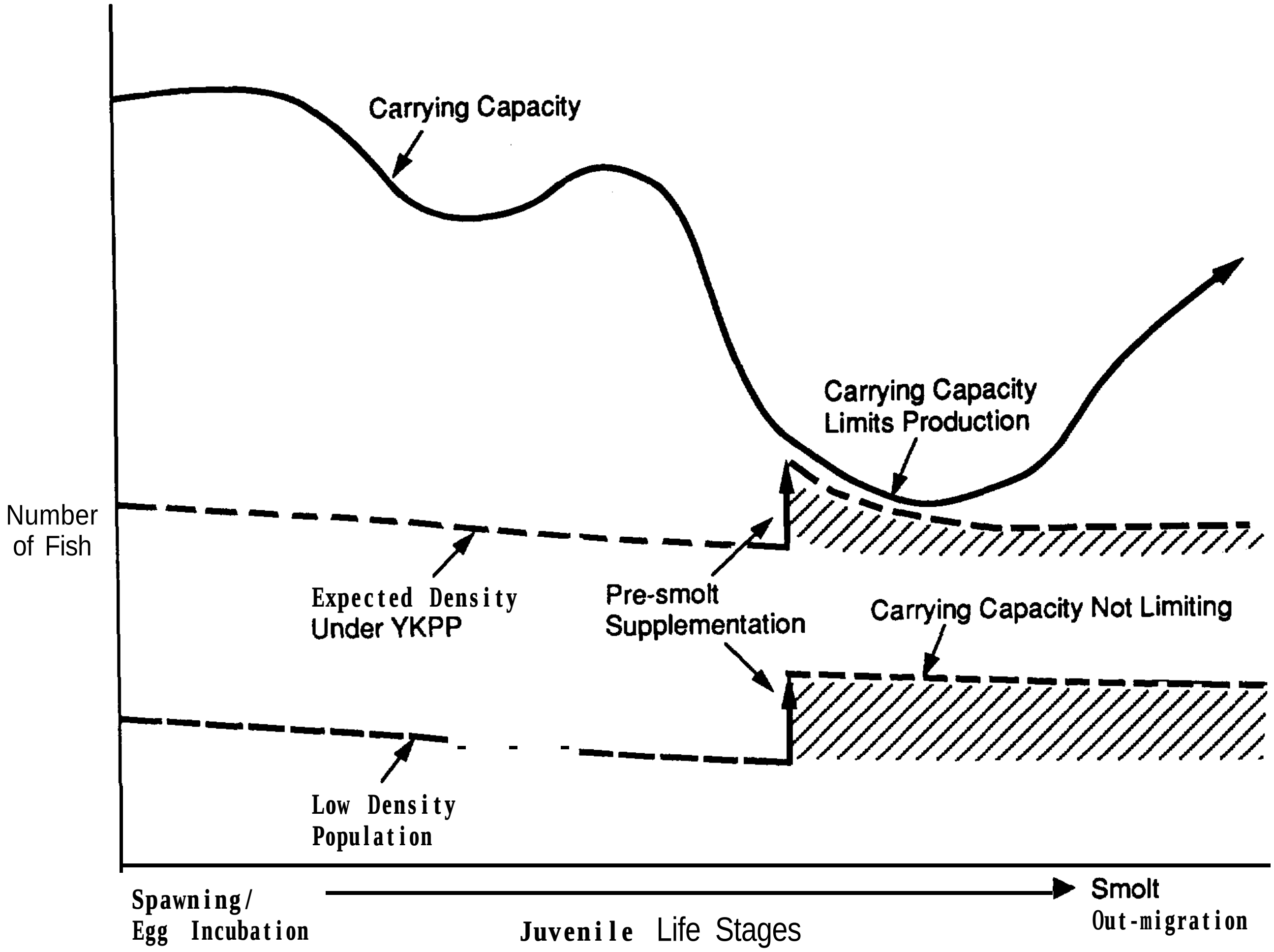

FIGURE 3.3. Relationship Between Relative Population Density and supplementation strategy. [This diagram illustrates how the density of a cohort relative to carrying capacity could affect the effectiveness of pre-smolt supplementation. When densities approach carrying capacity (as is expected under YKPP) pre-smolts must compete with natural smolts resulting in reduced survival of either or both groups. The lower dashed line shows how, in theory, pre-smolt supplementation is more effective at lower initial densities. The diagram also shows that at the time of out-migrations supplementation effectiveness is not constrained by carrying capacity.]

also may be a viable alternative in the re-establishment of populations in high-quality streams that are nearly or totally barren of anadromous salmonids, again depending on the specific circumstances (Figure 3.2).

The typical YKPP approach (e.g., Yakima spring chinook) may be viewed as an opportunity to manage the distribution of spawners within a drainage, thereby maximizing potential reproductive success and long-term productivity. This may occur, for example, by the application of the broodstock collection and mating guidelines (see Chapter 4.0, "Hatchery Operating Standards and Assumptions"), combined with use of geographically dispersed acclimation and release sites. In addition, hatchery spawners may be purposefully excluded from designated areas, which would serve as genetic refugia and/or experimental controls. For example, the American River has been designated a genetic refuge for spring chinook, while Satus Creek has been identified as a refuge, and probable control, for summer steelhead. In general, broodstock collection, mating strategies, and the magnitude of infusion of hatchery spawners in any geographical area is determined by guidelines rooted in genetics principles. The maintenance of genetic resources and diversity of supplemented stocks is a major concern. This is addressed, in part, by maintaining large natural spawning populations and avoiding intentional or unintentional selection on fish spawned and reared in the hatchery.

It is the intent of the YKPP to adhere to the strategies outlined in the Experimental Design Plan herein to the extent possible. Practical considerations, however, may require trying to optimize conflicting objectives. For example, a concept of mimicking natural smolt characteristics in the hatchery rearing cycle was considered a potential tool to maintain certain biological characteristics of adult returns (e.g., maturation rate and fecundity). The current hatchery release protocol for summer steelhead in the Yakima system, however, specifies yearling smolts rather than attempting to mirror the variable age composition of natural smolts (from ages 1 to 3). This decision recognizes potentially poor performance (post-release survival) of age-2 smolts and the experimental complications of managing test and control treatments under significant operational variability. In the Klickitat River, where hatchery water temperatures are expected to be quite cold, hatchery smolts are currently programmed for release at age 2, while natural smolts in the system are thought to be predominantly ages 2 and 3. Age at release also could bear on the obvious desire to maximize retention of genetic material from natural fish (broodstock) spawned and reared in an artificial environment. It should be noted in this particular example that the steelhead age at release question has not been fully resolved. Pre-facility work will examine a broader range of options.

3.5 EXPERIMENTAL GOAL

The YKPP has been designed to provide new knowledge regarding the application of supplementation techniques. The concept being explicitly tested is that supplementation can act to increase natural production through improved juvenile survival and increased production capacity (total hatchery plus natural smolt output is expected to exceed the natural capacity). The project's intent is to shift the systems' production potential from their current inherent levels to higher levels via continued smolt supplementation.

Numerous uncertainties exist that could impact the ability to achieve these objectives. Consequently, the experimental goals of the project have been emphasized in project design. The location of the basins in the Columbia system, below considerable hydroelectric development, and the extensive monitoring capabilities available provide unique opportunities to design and conduct experiments to resolve uncertainties which are critical to the choice and scope of strategies to meet stated objectives, with a high degree of confidence. The experimental concepts currently envisioned in the program are detailed in Chapters 5.0, "Experimental Program", and 6.0, "Population Response Criteria", while stock-specific experimental features are discussed in Chapter 7.0.

4.0 HATCHERY OPERATION STANDARDS AND ASSUMPTIONS

The intent of identifying hatchery production guidelines for the YKPP is to insure that basic goals and objectives of the project are met (i.e., that hatchery practices are consistent with the experimental plan). In addition, scientific standards for replicability are required for implementing the experimental plan. The operational standards and assumptions are continually being evaluated and reassessed as new information becomes available (Figure 2.1). As indicated below, in the form of pre-facility questions and information needs, the potential and, in some cases, likelihood of necessary changes in such things as hatchery guidelines, broodstock collection sites and production facilities is an important aspect of assuring that final project construction and implementation will conform to the underlying principles of the program. Final design of the project will allow for any necessary contingencies in this regard.

Hatchery practices (e.g., rearing density, diet, general fish culture techniques etc.) have not been considered the most critical uncertainties within the YKPP. Because of this and the fact that experimental opportunities will be limited during project implementation, hatchery practices generally will be managed as experimental "constants". This concept is important for minimizing annual variability and to insure that experimental conditions can be adequately replicated across years. However, several questions have been identified within the hatchery production cycle that need to be evaluated with respect to minimizing potential behavioral or genetic impacts from the hatchery program. These information needs are outlined below and will be addressed through pre-facility studies and planning efforts in order to formulate a final set of hatchery guidelines.

Current guidelines and information needs are outlined in three areas: 1) broodstock collection and mating, 2) rearing, and 3) acclimation and release. A quality control plan will also be required for project implementation to insure that experimental protocol are adhered to and that a system for monitoring and implementation is maintained. This plan, and its associated record keeping and communication systems, will be incorporated into a monitoring system to insure that hatchery production guidelines fall within pre-established tolerance limits.

4.1 BROODSTOCK COLLECTION AND MATING

The broodstock aspects of the hatchery program may be the most central to minimizing adverse genetic effects on natural populations. Several guidelines have been adopted that meet the genetic conservation intent of the project. These guidelines will contribute to maintenance of quality assurance aspects of the experimental plan (Allendorf and Ryman 1987; Gharrett and Shirley 1985; Hynes et al. 1981; Kapuscinski and Jacobsen 1987; Krueger et al. 1981; Hersvhberger and Iwamoto 1983; Seidel 1983; Withler 1988).

A centrally important issue in final design will be the identification of unique sub-stocks in the basins, as noted below. Broodstock collection and hatchery facility planning is proceeding under certain sub-stock assumptions that are being tested through pre-facility research. These assumptions are that there may be as many as three sub-stocks of spring chinook (American River, Naches River, and upper Yakima River) and three sub-stocks of steelhead (Satus/Toppenish Creeks, Naches Rivers, and upper Yakima river). These assumptions have implications for the location of broodstock collection facilities as well as experimental design.

On-going investigations may indicate sub-stocks are either more or less numerous than has been assumed. If there are fewer than three sub-stocks, existing experimental design is unaffected and broodstock collection practices can be simplified and perhaps consolidated. The discovery of more than the anticipated number of sub-stocks could necessitate some changes in anticipated procedures. These changes will, however, be relatively minor, and will not change either the facility requirements or the experimental design in a fundamental way.

As there are three clusters of acclimation/release sites in the Naches River system and five in the upper Yakima River, the existing experimental design can accommodate up to three supplemented sub-stocks in the Naches River and five in the upper Yakima River. Fewer sub-stocks pose no problem at the design level, as the existing design permits of blocking treatments over as many as eight sub-stocks. Indeed, the discovery of several additional sub-stocks would strengthen experimental design, as findings would then be demonstrated for a wider variety of fish.

Broodstock collection procedures can also accommodate a range in the number of sub-stocks. At the present time, it is anticipated that upper Yakima River and Naches River "sub-stocks" will be collected at Roza Dam and Cowiche Dam, respectively. There are also provisions for collecting broodstock at Prosser Dam. This ability could be utilized for sub-stocks that can be readily differentiated at Prosser Dam (as by run timing), or for a species or race existing as a single sub-stock throughout the basin. Although the American River and Satus Creek are designated as genetic refuges for spring chinook and steelhead and will not be supplemented, steelhead will be taken from Satus Creek for use broodstock in the supplementation of Toppenish Creek. The task becomes less complicated if fewer than the anticipated number of sub-stocks are discovered. Fewer sub-stocks require fewer collection facilities and, in the ultimate case of a single sub-stock (which is at least a logical possibility for steelhead), reduce to a single facility at Prosser Dam.

There are at least four overlapping strategies of accommodating the existing program to more than the anticipated number of sub-stocks. Three of these strategies are associated with the expedient of simply not supplementing smaller sub-stocks. First, it is of course possible to designate additional sub-stocks as genetic refuges, as is proposed for American River spring chinook. This strategy would obviously be appropriate for very small populations, for which the conflict between minimum effective population size and the maximum collection rate (20% of the run) conflict severely. This approach becomes more viable with the addition of the second and third strategies, improving in-basin smolt survival and/or reducing the terminal harvest rate. The survival of smolts from the upper reaches of the Yakima Basin to the Columbia can be surprisingly low--from 30 to 50% for wild/natural yearling smolts, and from 10 to 30% for hatchery-reared smolts. Smolt mortality on this magnitude obviously reduces productivity, and could threaten unsupplemented sub-stocks, especially when, as is contemplated, they are harvested at rates that maximize yield from the entire population (both supplemented and unsupplemented sub-stocks; see Section 7.1.1). The "security" of protected sub-stocks under YKPP management would be increased if the ongoing effort to reduce in-basin smolt losses by 50% is successfully implemented. The preservation of protected sub-stocks could also be promoted by the third strategy, which is simply to reduce terminal harvest rates. Finally, additional sub-stocks could themselves be supplemented. The supplementation of more than three sub-stocks would probably require the construction of additional collection facilities, and would require more effort in separately culturing fish at central rearing facilities. It should, however, be noted that such new collection facilities would probably be required only in tributaries, as reproductive isolation of conspecifics in the same general reach of the mainstem seems unlikely. Yakima River tributaries are relatively small; therefore, inexpensive, portable wiers could serve as collection facilities there.

Initial results from the stock identification work will be available in mid-1990 followed by expanded information in mid-1991. It is anticipated that any necessary facility contingencies can be met within the current final design schedule. In addition every distinct sub-stock in the basins will not necessarily be cultured in the program although their status would be an aspect of any long-term monitoring and evaluation plan.

Current guidelines for broodstock collection and mating are as follows:

Unique sub-stocks targeted for supplementation within the sub-basins will be individually cultured within the hatchery program.

Broodstock will be collected from progeny of natural spawners from these sub-stocks. (All hatchery fish will be marked to enable the selection of progeny from natural spawners.) In some cases natural stocks do not currently exist in the Yakima or Klickitat Basins. In those cases, this goal cannot be met initially.

A maximum of 10 to 20% of any natural-origin adult population (steelhead and spring chinook) will be collected for broodstock (see Refined Goals Report) to maintain a large, naturally reproducing gene pool.

Hatchery spawning groups will consist of at least 200 adults with equal numbers of each sex, using fertilization techniques to "equalize" the contribution potential of each male and female.

Representative portions of each run will be taken as gamete source in relationship to run timing and age/size composition. The use of jacks will be consistent with their potential to actually contribute in a natural spawning situation.

Random mating will be used.

Adults will be held according to disease policy guidelines of the State of Washington. Routine fish health screening will be conducted at the time of spawning to insure adherence to these guidelines.

Detailed records will be kept on all broodstock taken, including disease incidence, return time, age, size, sex, and genetic profiles (e.g., electrophoretic patterns). This information will serve both as a basis for racial/sub-stock separation of broodstock for mating and for comparing hatchery and naturally spawning stock characteristics annually and over time.

The following pre-facility questions and information needs have been identified in this area and have been incorporated in EDWG's annual working plan. Answers to these questions are required to develop the experimental design plan and to complete the facility design phase:

What genetically distinct sub-stocks of salmonids exist within the Yakima and Klickitat sub-basins?

What population characteristics should be used to define these sub-stocks and form the basis for long-term genetic monitoring?

Given existing hatchery production goals and answers to sub-stock questions above, what alternative broodstock collection and mating options exist to resolve conflicts between criteria for minimum population size and the maximum percentage of run used for broodstock (and consistent with the program's genetic objectives)? For example, are partially spawning female steelhead a viable strategy for increasing effective population size? For small natural populations being supplemented what is the balance of risk between increasing the 10 to 20% broodstock collection percentages versus reducing effective population size below proposed guidelines?

What selection impacts could occur from significant mortality of broodstock held in hatchery facilities for spawning?

What potential experimental constraints may result from disease incidence and management of hatchery broodstock and offspring and what contingency plans may be available to minimize long-term risks to the experimental program?

What implications do selective harvest mortalities have on brood stock collection and mating principles? For example, are we only trying to represent the age structure of natural stocks in a breeding program that reflects the results of selective fishing?

4.2 REARING

The general rearing objective is to produce smolts ready to migrate during or shortly after natural smolt emigration time, and at a size/age reflecting naturally-reared smolts. Emigration readiness is important to reduce competitive or predacious interactions with naturally rearing juveniles, while size and age consistency is important for maintaining the basic maturation, migration, and life history characteristics of naturally spawning stocks. While this objective appears reasonable for chinook and coho salmon stocks, the desired intent for mimicking natural smolt ages for steelhead has profound consequences on facility operations, experimental design, and interpretation of experimental results. Yakima River steelhead are currently programmed for 100% yearling release, whereas Klickitat River steelhead are programmed for release at age 2 (see Chapter 3.0, "Supplementation Goals," for further discussion). These current plans reflect a compromise between the biological ideal and practical operational/ experimental constraints. The implications of these strategies are still being evaluated. For example, size of steelhead smolts has a direct impact on both smolt-to-adult survival and ocean residence time or age at return (Ward et. al. 1989). While an operational hatchery objective may be to maximize smolt-to-adult survival by increasing smolt size, a primary objective of supplementing natural spawning with hatchery adult returns requires that hatchery practices (i.e. accelerated smolt size/age) not reduce age-at-maturity and fecundity to the point of impacting reproductive success or long-term fitness.

Other rearing guidelines include:

- Fish selected for experimental treatment or controls and subsequent planting should be selected from as many spawning adults as possible, by taking equal portions of egg groups rather than allocating total egg lots that represent a limited number of females.
- Uniform rearing conditions will be maintained among treatment and control groups.
- Rearing protocol will conform to disease policy guidelines of the State of Washington
- Detailed records will be maintained of disease incidence, growth, and smoltification.
- Densities will be lower than those typically used in the region's hatchery programs.

Several questions related to the rearing cycle have been identified and included in the annual working plan. Answers to these questions have critical importance in developing the experimental design plan and finalizing facility design:

- What rearing protocols exist that might enhance "training" for natural behavior (e.g., night feeding, continuous feeding, winter "starvation" etc)?
- To what extent will variation in juvenile size present operational and experimental quality control problems within the hatchery environment?
- What implications do current steelhead release strategies (including size grading, etc.) have on experimental response variables such as post-release survival and reproductive success?

How will juvenile rearing and release strategies impact or confuse comparisons of hatchery and wild population characteristics? For example, does size at release regulate age at return and, if so, how will age at return be used to monitor supplemented versus natural population characteristics.

How will juvenile rearing and release strategies affect potential for species' interactions (e.g., residualism).

4.3 ACCLIMATION AND RELEASE

Previously discussed guidelines will be standardized to meet project goals and objectives, and to provide quality assurance. In contrast, acclimation and release strategies represent a key area of experimental opportunity for the YKPP. Releases from acclimation sites will be the standard hatchery protocol. This strategy is expected to maximize survival, increase the potential for hatchery fish to successfully contribute to natural spawning escapement (optimal spawner distribution), and help prevent return of hatchery adults non-target spawning areas. Survival reductions for chinook salmon resulting from trucking and direct release have been documented by Fast et al. (1986, 1987, 1988, 1989) and O'Connor (1983). Schreck et al. (in press) found that transportation and release of coho salmon via trucking caused physiological stress that reduced survivability in the wild unless adequate recovery time was provided. Recent evidence further suggests that trucking and direct release of hatchery fall chinook smolts into the Umatilla River system may cause significant straying of adult returns into the Snake River system.[a]

Length of acclimation will be an important experimental variable for some locations. The standard acclimation time (initial control) has not been defined yet; however, at a minimum, it will be designed to allow recovery from the physiological stress of transportation and provide for an adequate level of imprinting. Other guidelines include:

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[a] Personal communication with R. Roller.

Acclimation "pond" water supplies should be drawn from the ambient source since an important purpose of acclimation is to minimize differences in immediate physiological stress and resultant mortality at release caused by differences in the rearing and release environment.

Juveniles will be transported to acclimation facilities within a 2-day period for related test and control groups.

- Volitional releases will be the preferred protocol.

Several questions related to acclimation and release have been identified and are also discussed in Chapter 5.0 "Experimental Program." . Answers to these questions are needed before the experimental plan can be finalized:

- What is the minimum acclimation time necessary to realize expected survival advantage?
- What effect will acclimation siting and duration have on spawner distribution and homing/straying?

What impact will volitional releases have on experimental quality control?

5.0 EXPERIMENTAL PROGRAM

The current design of the experimental program is described in detail in this chapter. It includes the overall approach, experimental standards, and hypotheses to be tested related to identified critical uncertainties.

5.1 EXPERIMENTAL CRITERIA

The purpose of the YKPP experimental program is to provide rigorous answers to issues relating to the central hypothesis of the program. Evaluation of previous supplementation programs have often produced negative or inconclusive results, or have been unable to separate the effects of supplementation from other confounding factors affecting fish abundance (Beck 1987). Sometimes this was due to insufficient funding; at other times study designs were inadequate to answer the questions posed. Nevertheless, previous experiences suggest four characteristics (i.e., statistical validity, replicability, stable funding, and communication of results) necessary for evaluation of the success of supplementation projects.

The foremost requirement is that the evaluation methods must be conceptually sound and statistically valid. Past evaluation of supplementation, if done at all, tended to focus on measurements of local population change. However, comparisons of abundance over time or pre-supplementation and post-supplementation population size cannot be causally linked to an effect if adequate control groups are not used. For instance, a postsupplementation increase in the number of spawning adults may have occurred anyway as a result of improved ocean survival or a decreased harvest rate. Conversely, supplementation may have been successful even though population size decreased due to the effect of an unmeasured mortality factor.

The primary reason previous supplementation efforts have produced inconclusive results is that program managers often did not, for a variety of reasons, account for the two types of natural variability (i.e., experimental measurement error and temporal variation). Failure to properly estimate both types of variation has led to confusing results, especially where the effects of supplementation could not be separated from natural variation. Adequate replication of treatment and control groups is needed to estimate the magnitude of variation due to measurement error. Additionally, replicate treatment and control areas must be designed and implemented to assure they are truly comparable and sufficient in number. For example, the use of natural features such as oxbow ponds or control streams would severely limit the number of replicates available for experimentation. Additionally, results could be affected by unique conditions within each pond or control stream. Indeed, in many areas a sufficient number of natural treatment areas do not exist to conduct even the most basic type of experimental design in a statistically sound manner.

The need to control the effects of natural temporal variability is less appreciated. Study designs need to include considerations for population parameters (e.g., survival, growth, age and, sex ratios) that exhibit annual fluctuations due to the interactions of organisms with each other and with their environment. Traditionally, failure to estimate temporal variation has resulted in confusing results from many study approaches that attempt to compare baseline and posttreatment conditions.

The absolute need to account for both types of experimental variation has led to the adoption of a "staircase" approach to experimental design under the YKPP (Figure 5.1). Under this protocol, treatment and control groups of fish are replicated both within a year (to estimate measurement error) and over a period of years (to estimate temporal variation). In fact, there must be a commitment to continue the control group throughout the duration of the study. This provides a "baseline" through time, or a temporal control, against which the relative performance of various treatment groups (continuing for several years but not indefinitely) could be compared. Annual review would determine whether to discontinue the treatment group having the poorest performance and whether to add new treatment groups. These decisions would be based upon the magnitude of the difference in performance. For example, an extremely poor performing treatment might need to be included for only 1 or 2 years, while treatments having smaller performance differences might require repetition over several years to achieve the same degree of statistical precision. The control group would be continued throughout the study, regardless of performance, to provide a consistent baseline for comparison.

Years	Control	Treatments															
		A	B	C	D	E	F	G	H	I	J	K	L	M	•	•	•
1	1	3	2														
2	1	4	2	3													
3	1		3	4	2												
4	3		4	5	2	1											
5	4		6		3	2	1	5									
6	5				4	3	1		2	2							
7	5				4	4	2		3	2	1	6					
8	4					4	2		3	2	1		2				
9	3						2		3	2	1		2				
10	3									2	1		2	2			
•	•																
•	•																
•	•																

FIGURE 5.1. Example of a "Staircase" Design. In order to account for and evaluate annual effects and interactions between treatments and annual variables, treatment must be repeated for several years. The numbers in the table represent performance rank within a year for each of the treatments (including control). Note that control treatment remains the same throughout the study in spite of declining performance relative to other treatments. With a few exceptions treatments are continued for 4 years or more. (Prematurely discontinued treatments might include those that proved more difficult or impractical to administer than initially expected.)

The only way to account for the effect of a single action (supplementation) is to conduct evaluations so the effect of competing causes can be detected and measured. This requires a statistically valid experimental design using replicated treatment and control populations. Only in this way can the natural variation in the size of fish populations be estimated and the change due to a single intervention be detected.

A second essential characteristic (i.e., if evaluations are to have basin wide application) is that the studies be conducted in such a way that they can be repeated over time, both with the same population and with populations in other basins. Interpretation and extrapolation of information from one area or time period to others has been a major problem in recent system planning efforts. The difficulty lies with our inability to classify a particular observation as attributable to a local phenomenon or an underlying general pattern. Study methods that differ between areas or over time complicate the problem. The overall understanding of salmonid production in the Columbia Basin will not have been advanced unless other groups apply similar approaches and obtain comparable results.

Another very important reason for replication over time is to characterize, quantify, and interpret treatment by year interactions. Depending on yearly conditions, a long term beneficial treatment may be masked by annual conditions that favor a "normally" less successful treatment.

Finally, the results of evaluations must be made easily and widely available to interested parties. One only has to look back at the difficulty of summarizing past knowledge to appreciate the need for better communication and retrieval of results from supplementation efforts. At least three times during the brief history of the Fish and Wildlife Program, summaries of knowledge gained from supplementation programs have been developed. An effective information system should incorporate our existing knowledge of supplementation results, add new information as it becomes available, and allow efficient summarization and retrieval of results.

5.2 THE EXPERIMENTAL PROCESS

An ordered sequence of development offers the best chance of success when designing a program of this nature. Such an approach should proceed from the general to the more specific elements of the program design, with each successive level of detail consistent with the levels preceding it. Given the existing unanswered questions, it is unlikely the first design will remain unchanged. Therefore, the YKPP experimental design is an iterative process using knowledge gained at each step to refine future actions.

There are at least three identifiable iterations that will occur in refining the experimental design by the time hatchery production starts. The first iteration (this report) uses presently available information from the literature and ongoing studies in the Yakima Basin to develop the initial experimental program. Pre-facility studies described in annually-revised working plans will provide information for the second iteration of refining the experimental program. Depending on experience gained during pre-facility studies, there may be two iterations prior to the availability of hatchery-reared fish. The third stage of refinement (i.e., structured hypotheses testing) will occur after hatchery reared fish become available.

Each iteration of the experimental program design will involve several basic steps. First, identification of critical uncertainties will lead to framing hypotheses for experimental testing. This step will be followed by identification of appropriate response variables, specification of the level of statistical accuracy desired, and design of the actual experiments and monitoring programs. The final step in this process will be to re-examine and modify previous uncertainties and hypotheses based upon results of the experimental program. In this way, the quality of results will be assured, and the rate of learning will be maximized.

5.3 OPERATIONAL GUIDELINES

The types of considerations discussed for the present experimental program have led to the development of a set of initial operational standards. These standards will be evaluated and refined as pre-facility work progresses. For example, the following statistical criteria will be applied to this program whenever possible:

- Control groups will be identified and the most efficient experimental design feasible will be applied. Three types of control treatments are defined below. A valid control group should differ from treatment groups against which it is compared only in the attribute that defines the treatment. As a matter of practicality in studies of this kind this is often difficult to achieve. The more variation in other attributes (e.g., habitat or stock type) the more spatial-temporal replication and repetition of experiments is needed to arrive at valid conclusions. The fact that ideal experimental controls are sometimes difficult to find must be (and is) compensated for by a strong commitment to the scope and duration of the YKPP experimental program. The three control types are:

Type 1 or "broad natural production" controls. Since the principal hypothesis of the YKPP is that "supplementation works" (i.e., natural production and harvest can be increased on a sustained basis), identification of sub-populations as controls, which will not be supplemented (or affected by supplementation elsewhere), must be considered. Finding such populations is extremely difficult, since sub-populations, tend to 1) be genetically different (as is the case with American River spring chinook), 2) interact through straying, or 3) are subjected to different environmental factors (different hazards on the route from smolt to spawner). Limited opportunities do exist however for steelhead, where a set of tributaries of Satus Creek will be used as control streams against supplementation treated tributaries of Toppenish and Cowiche Creeks. The same stock of fish will be studied in these streams, how effectively potential confounding effects can be controlled is uncertain.

Type 2 or "local relative" controls. Supplementation success requires: 1) that spawners taken to the hatchery for mating, incubation, and rearing produce more returning adults than do natural spawners (see discussion in Chapter 6.0 on post-release survival), 2) that returning supplementation fish are able to reproduce in the wild (see discussion in Chapter 6.0 about reproductive success), 3) that supplemented populations remain genetically fit (see discussion on long-term fitness in Chapter 6.0). Success requires certain levels of performance in terms of each of these population responses (note that performance in (1) may compensate for (2) and vice versa). On the basis of theory about how supplementation operates, these broad areas may be reduced to more specific and measurable response variables, which are reflective of supplementation-induced changes to the population. Thus for example naturally produced smolt in supplemented streams may serve as controls to outplanted smolts in comparing survival from smolt to adult. Much of the planned pre-facility work focuses on the identification and measurement of response variables associated with reproductive success and fitness.

Type 3 uses a "supplementation standard" as control. In studying alternative supplementation treatments one treatment will always be labeled control. This treatment will be continued over the duration of the study regardless of performance relative to other treatments.

- All treatment and control groups will be replicated (each year). As a general rule a minimum of 3 replicates will be used for each treatment and control group.

- Sample sizes (numbers of fish per treatment group) and the number of replicates per treatment are set to optimize statistical power. Statistical power measures the ability of statistical tests to conclude that treatments differ when in fact they do. The power of such tests increase with sample size (and with the number of replicates), but there are practical limits to how much it can be increased. Because of natural variation in fish behavior and its measurement (though tagging) the rate of increase in power as a function of sample size becomes slow beyond some optimum. DeLibero (1986) investigated this natural variation in estimation of survival from smolt to adult for coded wire tag (CWT) experiments and concluded that the optimum number of recoveries for such experiments was 35 per replicate. He estimated the coefficient of variation (CV), (which is standard deviation divided by the mean), for survival data to be about 25%. Whereas the CV will be affected by the number of replicates chosen, the optimal recovery number will not.[a] The sample sizes proposed in this report are based on an expected recovery of 35 adult survivors per replicate. If a CV of 25% is achieved with 3 replicates per treatment, the approximate power of a 10% (significance level) test is 90% when treatments in fact differ by a factor of 2. Smaller differences will be detected with less power. Refinement of sample size requirements are expected, as more information

(a) Personal communication with Delibero.

on variability is obtained and as new methods (e.g., PIT tagging) are tested. This new information will not change the number of fish per release group, but may reduce the number of fish that are marked in each group. Note, for example, that PIT tag recovery rates may be as much as 10 times as high as CWT rates in the terminal areas; it may also allow more powerful statistical methods to be used. All of these factors contribute to the potential for increasing statistical power.

- A "staircase" design will be employed wherein treatments are repeated sequentially through time. Replication over time is essential in order to test interactions between treatment and year. Conditions in different years may affect treatment comparisons. A long term beneficial treatment may go undetected in any given year because of such interactions. There is a further commitment to continue control treatments throughout the study (see Figure 5.1).

Our intent is to use methods that have the greatest likelihood being used in other areas whenever feasible. Use of video tapes as training tools and as a means of documenting the studies conducted will also be explored. Methods and results will be recorded in a manner facilitating rapid dissemination and easy access by others. Efficient data handling procedures will also be employed to insure that information storage and retrieval is coordinated with other efforts in the Yakima Basin and at the system-wide level. This will enhance repeatability of experimental conditions and promote overall quality control.

6.0 POPULATION RESPONSES

The overall goal of the YKPP experimental program is to test the central hypothesis that new artificial production in the Yakima and Klickitat sub-basins can be used to increase harvest and enhance natural production without adversely affecting genetic resources. Acceptance of the central hypothesis would imply that production increases can be achieved using artificial spawning, incubation, and rearing technologies with no significant loss in fitness of pre-existing natural stocks and no undesirable impacts on other stocks.

Determination of the extent to which the central experimental hypothesis of the YKPP has been achieved will require evaluation of four major population responses: 1) post-release survival of hatchery fish, 2) reproductive success of supplemented populations; 3) long-term fitness of supplemented populations, and 4) inter-specific and intra-specific ecological interactions. Opportunities and constraints for measurement of each of these four population-response variables are complex and will depend on the development of specific experimental approaches and evaluation tools which utilize control features appropriate for assessment of the particular population response. A general discussion of control and treatment concepts is presented in Section 5.3. Refinement of specific monitoring and evaluation components for each variable will be based on data provided by pre-facility research. The relative importance of each response will vary among stocks and will be reflected in the discussion of stock-specific experimental considerations found in Chapter 7.0. It is important to note that the standard for comparison (to determine relative supplementation success) will be characteristics of natural fish. Each of the four population responses are discussed in more detail in the following text.

6.1 POST-RELEASE SURVIVAL OF HATCHERY FISH

Major post-release losses are a common element of many if not most out-programs. Minimizing this mortality is critical to the success of supplementation. Post-release survival, which pertains to all supplemented species, is defined as survival from release through outmigration, fishery interception, return to the sub-basin (including possible straying to streams other than the stream of origin), and spawning. Measurable components of post-release survival include smolt to smolt survival rates and pre-smolt-to-smolt survival if pre-smolts are outplanted at various time intervals and at various locations, rates of downstream migration of juveniles and upstream migration of adults, smolt-to-adult survival rates, harvest rates, marine survival rates, and accuracy of homing. In addition, abiotic or non-controlled factors may exert a strong influence on post-release survival. Such factors include variable instream conditions within and among years (e.g., water quality, flow rates, temperature; upstream and downstream fish passage obstructions; land-management and development activities; and environmental conditions in estuarine and marine rearing areas).

Because of its potential influence on the success of the YKPP, determination of the extent and causes of smolt-to-smolt mortality has been identified as a critical pre-facility information need. In addition, experimentation with Type 3 control (see Section 5.3) treatment groups to improve post-release survival should be a high-priority YKPP activity.

Information on post-release mortality of hatchery fish will be compared with information obtained for wild fish. Assessment of the differential in mortality at these life stages will aid in the determination of overall program success.

6.2 REPRODUCTIVE SUCCESS OF SUPPLEMENTED POPULATIONS

It will be necessary to determine the reproductive success of supplemented stocks to meet the goals of the YKPP. Reproductive success is a measure of relatively short-term performance, which is broadly defined as the contribution of an individual to the next generation. If the number of fish produced increases from one generation to the next, then change in reproductive success would be considered to be positive. Conversely, if the number of fish declines, then the change in reproductive success would be negative. The YKPP emphasizes the reproductive success of naturally spawning adults, defined specifically as the number of offspring produced per spawner. Offspring survival (thus reproductive success) can be estimated through various life history stages such as fry, smolt, or adult. Reproductive success comparisons among life stages allow inferences to be made regarding critical periods and influences experienced by supplementation fish, and should aid in the measurement of the genetic component of this variable. It is important to note that reproductive success is essentially a phenotypic measure that may or may not have a substantial genetic component.

Pre-existing stocks of spring chinook, fall chinook and steelhead stocks found in the YKPP area are adapted to varying degrees (considering past and present hatchery releases, strays, etc.) to local conditions. In contrast, the intent of YKPP is to use non-local stocks to re-establish runs which are extirpated or severely depressed (e.g., coho, summer chinook and sockeye). Production attributable to supplementation fish must be separated from that attributable to pre-existing wild fish before the supplementation program can be evaluated. In this context, reproductive success can be considered to be "reproductive efficiency," which is positive for supplementation fish if and only if their reproductive success is equal to or greater than that of wild fish. This aspect of reproductive success is also related to estimation of fitness, discussed as a separate response variable later.

There is no single, all-encompassing measure of reproductive success in the context of YKPP. It will be necessary to obtain and assimilate information from a variety of sources, methodologies and controlled experimental approaches (Section 5.3). Many population censuring and enumeration techniques can be used to estimate survival through various life history stages (Fast et al. 1986). Investigation of these techniques is a vital component of pre-facility research. Similarly, establishment of monitoring capabilities is also critical for estimation of needed parameters such as smolt yield, survival, juvenile and adult age composition, and origin. Evaluation of habitat characteristics and estimation of carrying capacity are critical to the assessment of reproductive success. Once the YKPP is operational, estimates of escapement, carrying capacity, and habitat availability might allow predictions to be made regarding the production potential of pre-existing stocks and the relative contribution of offspring from supplementation fish. Stock identification techniques using external tags may be used solely or in concert with electrophoretic markers. Genetic stock identification (GSI, Pella and Milner 1987) studies may provide information on fisheries harvest.

A pre-facility planning need exists to identify and refine the specific parameters and measurement methods needed to evaluate reproductive success. Approaches include comparisons between supplemented (treatment) and unsupplemented (control) tributaries, and comparison of reproductive success between natural and out-planted fish in the same stream using genetic marking techniques. Once methods are identified and prioritized, pre-facility studies are needed to develop operational approaches consistent with the experimental plan.

6.3 LONG-TERM FITNESS OF SUPPLEMENTED POPULATIONS

The genetic concept of "fitness" can have different meanings depending on the context in which it is applied (Falconer 1981; Hedrick 1983; Kapuscinski and Jacobsen 1987).

In the context of YKPP, long-term fitness refers simply to the genetic component of reproductive success. Maintenance of population fitness per the goals of YKPP precludes: 1) having a negative influence on genetic diversity (decreasing the amount of genetic variation within and among populations), 2) accelerating the rate of genetic change beyond that normally expected due to genetic drift and natural selection, and 3) artificially directing or changing selective pressures.

Measurement of long-term fitness is a challenging aspect of pre-facility work efforts and planning. Genetics monitoring, including stock identification and short- and long-term estimation of genetic diversity and genetic change will be addressed utilizing electrophoretic and related methodologies during both pre-facility and implementation phases. Information on the intensity of artificial selection will be available from such data, coupled with an ongoing assessment of hatchery production quality control guidelines and any related experimentation. A major element of an evaluation of long-term fitness pertains to performance characteristics (i.e., survival). The survival of supplementation fish versus non-supplementation fish may be best approach using genetic marking studies. Approaches and alternatives to such studies are now being addressed as a part of pre-facility work activities. Genetic marking studies allow offspring of supplementation fish to be identified and allow evaluation of relative performance under natural conditions and over multiple generations (Chilcote et. al. 1986). Long-term monitoring of population dynamic features, such as population abundance, distribution, life history characteristics (e.g., age, size, etc.), and morphometric features (e.g., fluctuating asymmetry of bilateral meristic characters; Leary et al. 1985), will also be required to aid in the interpretation of genetic fitness information.

Measurement and monitoring of long-term fitness will require consideration of experimental control treatment options similar to those previously discussed for reproductive success. Options include examination of unsupplemented streams and relative comparisons between natural and supplemented fish within a given stream (i.e., genetic marking methods). A major pre-facility need exists to develop and refine a genetic monitoring and evaluation plan that measures the varied aspects of this population response.

6.4 SPECIES INTERACTIONS

As a population response, species interactions are defined as those ecological interactions that may limit or otherwise impact another species of interest. The ability of supplementation programs to increase natural production may be influenced by the occurrence of ecological interactions between supplementation fish and/or their progeny, and one or more pre-existing fish populations. Depending on the characteristics of the species involved (e.g., life history, abundance, size, distribution), such interactions may favor either the preexisting or supplemented component of a given stock. Measurable components of species interactions attributes such as abundance and distribution, food habits, growth rates, predation, carrying capacity, survival rates and other behavioral aspects involving displacement due to competitive interactions. Minimizing the effects of inter-specific and intra-specific interactions should result in maintenance of an optimum balance among all stocks of concern. The potential for negative effects of YKPP on existing stocks is of substantial interest. The most notable is the potential interaction between supplemented steelhead and resident trout. Determination of the potential for such interactions has been identified as an important pre-facility information need. Pre-facility assessment of this potential will include the development of baseline information on rainbow trout and is expected to involve controlled experimentation in treatment and control streams.

7.0 STOCK-SPECIFIC EXPERIMENTAL FEATURES

The following sections outline supplementation objectives (YIN et al. 1988), critical uncertainties, and experimental protocols for each of the stocks to be supplemented under the YKPP. Supplementation objectives are taken from the project's Refined Goal Report (YIN et al. 1990). The assumptions entailed by species-specific objectives, proposed facilities, and production levels are described in terms consistent with the Council's System Planning Model.

Critical Uncertainties are discussed for each stock to be supplemented in terms of expected effects of different production treatments on each of the population responses. A critical uncertainty is defined as an uncertainty that significantly affects the choice and scope of actions that best meet the stated objectives. Resolution of these uncertainties is critical to effective implementation and operation of supplementation programs in the Columbia Basin, in general, and in the YKPP, specifically. This resolution and communication/implementation of experimental results is the purpose of the YKPP's experimental program. The critical uncertainties are discussed within the four population response categories previously discussed. Pre-facility information needs that are necessary to allow design of experimental approaches are identified.

Experimental design is outlined for each stock to the level of detail that current planning permits. Experimental hypotheses that are intended to resolve critical uncertainties of the project are presented. While these hypotheses are subject to revision via the annual process of experimental plan refinement, such revisions are not expected to change facility design needs to the point where reasonable contingency options are not available. Requirements for monitoring response variables, as needed for hypothesis testing, are discussed in Chapter 8.0, "Monitoring Program." Experimental protocols are also identified within the experimental design subsections and identify various facility requirements of the project, both at the central incubation and rearing sites as well as at offsite acclimation and release locations.

For each null hypothesis in the experimental design sections an alternate hvoothesis is stated. It describes the state of nature where we expect to reject the null hypothesis with a high probability (i.e., statistical power) when a significance level of 10% or less is used in the test. The power against the stated alternatives is expected to exceed 80% in most cases. The power of each test depends upon sampling intensity and the natural variability of the response variables. As stated in Section 5.3 the general standards are set on the basis of expected variation in estimated survival from smolt-to-adult; when, however, survival to outmigrant smolt at Prosser is an appropriate measure of the population response, higher standards may be set. Further refinement of experimental designs are expected as response variables associated with reproductive success and long term fitness are more clearly identified and their statistical properties better understood. It is, however, safe to assume that adult survival experiments will impose the most severe demands on the design of rearing and release facilities. As stated earlier, these requirements are met by the current facility design. Results of pre-facility studies regarding identification and monitoring of additional response variables and identification of sub-stocks may affect broodstock collection and monitoring facilities. The monitoring program described in Chapter 8.0 and the facility requirements identified in Chapter 9.0 represent the most likely needs based on current knowledge. Facility design and monitoring programs were designed to be flexible enough to accommodate changes dictated by new knowledge (see Section 4.1).

It is important to note that these stock-specific sections outline only the current status of experimental planning. The intent is to complete the experimental plan and final facility design/construction in concert. The post-release hypotheses and experimental protocols that will be fully elaborated address only those uncertainties amenable to straightforward experimental designs, such as the benefits of acclimation time. Other, experimentally complex uncertainties, such as those relating to reproductive success, long-term fitness and species interactions, have to-date been analyzed only in general terms, and are not associated with explicit hypotheses and experimental protocols. In such areas, current emphasis is on pre-facility studies that will generate the data from which definitive experiments can be fashioned.

The reader should clearly note that all of the hypotheses identified in the following sections cannot be tested simultaneously. The experimental designs have a yearly dimension, where new treatments and hypotheses are introduced over time subject to the "staircase" design principle described in Section 5.3. The prioritization of hypotheses will be reviewed and refined annually as new knowledge is gained. High priority hypotheses are identified here to insure their accommodation by facility design, and not necessarily to suggest the order of priority.

7.1 YAKIMA BASIN SPRING CHINOOK

7.1.1 Supplementation Objective

The refined goal is to increase the adult spring chinook production potential in the Yakima Basin by about 65% from the current level, while preserving the genetically unique run in the American River. It is currently anticipated that smolt out-plants of 1,646,000 will achieve this goal. Under existing conditions of habitat quality and quantity, out-plants are expected to comprise about 55% of the total adult return to the basin. A supplemented fishery managed for MSY to all fisheries is estimated to generate a total run size (including ocean harvest) of 16,475, and a run size to the mouth of the Yakima River of 9,353. These figures were estimated by the Council's System Planning Model, and incorporate the best available estimates of carrying capacity, survival, and other population parameters.

The projected run sizes to the American River under supplementation require some explanation. The American River is to be maintained as an unsupplemented, genetic sanctuary. Nevertheless, so long as adequate escapements can be maintained, it will be harvested at a rate that maximizes yield to the entire fishery. As survival of supplemented stocks increases, MSY terminal harvest rates also increases, causing a decrease in the abundance of American River spring chinook. This situation is especially true under existing conditions of in-basin smolt survival. Due to a disproportionate clustering of poorly screened irrigation diversions and reaches of partial dewatering in the Naches River system, American River fish suffer as much as 40% higher smolt mortality than do upper Yakima River fish, and therefore are relatively more vulnerable to over-fishing. Thus, for example, under existinq conditions, as supplementation success increases from 30 to 60%, American River escapement falls from 76% of baseline (MSY escapement under existing conditions without supplementation) to 9% (from 434 to 52 fish). However, it is essential to note that programs are already under way to improve in-basin smolt survival (in the American River as well as the entire drainage). The Council's "Phase-II" screening program is expected to result in the rebuilding of all inadequate screening systems in current production areas, and EDWG is currently designing a study to determine the magnitude and location of smolt losses in the open river, with the ultimate intention of developing a program to halve smolt losses. If all screens are brought up to current standards, and if open-river losses are reduced by 50% (perhaps as a result of a predator control program), supplementation would pose no threat to the American River stock. In fact, the System Planning Model predicts American River escapement would then increase by 80%, even under higher exploitation rates. It should also be noted that the System Planning Model indicates in-basin smolt survival would more than double the total run size of the population. With varying degrees of emphasis--more for species rearing higher in the system, like spring chinook and steelhead, and less for "low-rearing" species like fall chinook--this pattern of increased productivity is expected for all species targeted by the YKPP. Improved in-basin smolt survival enhances the effectiveness of the YKPP more than any other single measure.

7.1.1.1 Assumotions

The refined supplementation goal for all species targeted by the YKPP entails a number of assumptions. The assumptions listed below for spring chinook are common to almost all targeted species. Unless specifically mentioned in subsequent sections, it should be understood that the assumptions underlying the spring chinook supplementation goal apply to other species and races as well. The spring chinook assumptions are as follows:

1. Normal survival from spawner to smolt can be achieved through hatchery practices (not reaarded as an uncertainty).

2. Post-release survival of hatchery fish is approximately 60% of the natural smolt survival. Observed survival of hatchery smolts have generally been on the order of 10% of the natural rate. It is assumed that the manner of release of hatchery smolts into the environment can raise relative survival to as much as 60% of the natural rate.
3. Adult returns from hatchery outplants will distribute evenly over the available spawning area in the general vicinity of the point of release.
4. Hatchery and natural spawners (in the F1 generation only) will mate at random with 80% efficiency for N x H and 50% efficiency for H x H (based on 100% efficiency for N x N).
5. There is no reduction in reproductive success as a result of continued supplementation (i.e., no second generation difference in reproductive success).
6. Natural production will approach the basin carrying capacity estimates, and the addition of supplementation fish will not significantly reduce the long term productive capability of the natural spawning population.
7. Passage improvements currently proposed for mainstem Columbia hydroelectric facilities will be realized by the time YKPP comes on line (both existing and supplemented scenarios incorporate improved mainstem Columbia passage).

7.1.2 Critical Uncertainties

7.1.2.1 Post-Release Survival

Current hatchery practice is to grow smolts as big and as fast as possible because large size is often associated with higher survival rates to adult. The intention of the YKPP is to standardize the hatchery rearing practices to produce a smolt that mirrors the wild fish as closely as possible. This will include rearing at lower densities than normal in hatcheries. Currently, there are no plans to test the assumption that hatchery smolts that reflect natural smolts in age and size will survive better over time (i.e., over several generations).

7.1.2.1.1 Pre-Facilitv Needs. Preliminary studies indicate that mortality is as high as 50 to 60% for natural spring chinook smolts during their emigration from upper basins to Prosser. Further studies need to be conducted to estimate site-specific survival and the cause(s) of smolt mortality in specific reaches.

This critical uncertainty of post-release survival is a pre-facility need that should be resolved before the production facility is on line. Studies are currently being designed to refine the mortality estimates and identify sources of mortality in order to improve outmigration survival rates. Improved understanding of in-basin (Yakima) smolt survival will suggest measures that could improve survival of all smolts and accelerate the rebuilding process.

In addition to the high mortality experienced by naturally produced smolts, hatchery-reared smolts are subject to an additional post-release mortality thought to be caused by a lack of "conditioning" to the natural environment. At this time, the effects of acclimation and release strategy on post-release survival of hatchery reared fish are not fully understood. Physiological recovery from the stress of transport and, perhaps, the acquisition of adaptive patterns of behavior (e.g., predator avoidance and natural feeding behavior), are two possible mechanisms that could enhance the survival of acclimated smolts. Whatever the mechanism, it is hypothesized that acclimation will reduce the post-release mortality usually experienced by hatchery fish, and that this will result in greater survival to adulthood. Recent studies of spring chinook in the Yakima Basin indicate that smolts released volitionally from acclimation facilities have a higher survival rate, to the Prosser smolt-counting facility and to returning adult, than do fish released directly into the river (Fast et. al. 1986).

Experience throughout the region demonstrates the importance of broodstock selection and low density rearing in fish culture. The major untested uncertainties involve strategies for introducing fish into the natural environment in a manner that will maximize survival. These tests are a key to the experimental design of the operational phase of the project.

7.1.2.2 Reproductive Success

The reproductive success of supplemented populations is an important link in the long-term success of the YKPP. Short-term reproductive success (one generation) depends on the hatchery-reared fish homing to the acclimation area from which they were released as smolts and on their ability to successfully spawn at a rate equal to some percentage of naturally-produced fish as stated in the assumptions discussed in Chapter 3.0.

7.1.2.2.1 Pre-Facility Needs. Pre-facility needs for the monitoring of reproductive success include:

1. Develooment of the ability to determine whether supplementation fish as spawners home to their area of release. A corollary need is the determination of whether or not these fish disperse throughout the general release area, therebv maximizins their chances of reproductive success. Methods that might be used to monitor homing ability include radiotagging, coded-wired tag recoveries from spawned-out carcasses, weirs in smaller tributaries, and/or PIT tag detectors in fish ladders at various dams in the basin. It should be noted that even fool-proof PIT tag detectors at Roza Dam on the Yakima River and Cowiche Dam on the lower Naches River would not allow the determination whether fish successfully homed to release areas in the upper portion of either drainage. PIT tag detectors at these points would, however, provide a record of the straying of Yakima River fish to the Naches River and visa versa. Methods with greater site-specificity, such as wiers on particular spawning grounds or tag recovery from spawned-out carcasses, will be used to assess homing or straying within a sub-basin.

2. Develooment of methods to auantifv the reproductive success of first generation supplementation fish relative to natural spawners. Soecificallv, methods should be developed to test the assumptions incorporated in the System Planninq Model: that a matinq between two hatchery fish produces 50% as many offsprinq as two natural spawners, and that a hybrid matins produces 80% as many offsprins as an all-natural mating. Potential methods of monitoring include redd-capping to capture emergent fry of known-origin spawners and/or the use of genetic markers. Genetic marking technique may allow monitoring through successive generations.

One of the major uncertainties of the YKPP concerns the ability of supplemented spring chinook populations to reproduce successfully. The effect of different supplementation strategies on reproductive success is a principal post-facility study objective.

7.1.2.3 Lona-Term Fitness

Geneticists reserve their greatest genetic concern for Yakima River spring chinook. Stocking of hatchery fish has been relatively unsuccessful in the past, and all current production is from natural spawning. For this reason many of the critical questions concerning spring chinook involve measuring the genetic effect of using hatchery-reared "native" stock to supplement natural production. Experiments will be designed to evaluate the survival of fish produced for supplementation. These studies will focus on egg-to-smolt and smolt-to-adult survival of the offsprinq of supplementation fish in successive generations. Critical uncertainties and hypotheses relating to survival and genetics are formulated for the two areas of concern--broodstock selection and rearing, and release strategies.

7.1.2.3.1 Pre-Facility and Post-Facility Needs. The critical uncertainties associated with the genetic structure of Yakima spring chinook are an important pre-facility need. This need is being addressed in an ongoing study conducted by the WDF. WDF's research will establish the number and distribution of genetically distinct sub-stocks in the basin, and will circumscribe acceptable broodstock selection practices. A related and equally important post-facility need is the development of the ability to monitor genetic changes that could be caused by supplementation. This need is also included in WDF's pre-facility genetic monitoring plan.

Pre-facility needs for determining long-term fitness will focus on developing methods to monitor the reproductive success of supplementation fish through many generations. In addition, this work will establish procedures to identify adverse genetic effects occurring in the entire supplemented population--naturally spawning fish as well as first generation supplementation fish.

7.1.2.4 Species Interactions

If potentially significant intra-specific and inter-specific interactions are identified during the pre-facility data collection period, EDWG will design studies to monitor and evaluate them.

7.1.2.4.1 Pre-Facility Needs. The need to evaluate possible interactions involving supplemented spring chinook populations will be assessed. In particular, there may be a need to determine the potential for intra-specific interactions, particularly as regards movement of hatchery pre-smolts from tributaries to mainstem reaches in the winter months.

Intra-specific and inter-specific interactions are not anticipated to be a major concern for spring chinook.

7.1.3 Experimental Design

The experimental design for the Upper Yakima River Spring Chinook is currently planned to evaluate the effects of length of acclimation period on the survival and homing of released smolts. There will be five geographic locations (three mainstem and two tributary) with three pond sites each for a total of 15 ponds in the upper Yakima River. This design will allow testing of one "control" acclimation time period and two treatment periods with five replicates of each treatment. Each release group will consist of 75,000 smolts for a total of 1,125,000 test fish.

The experimental design for the Naches River anticipates testing effects of acclimation time on reproductive success and long term fitness (Hypotheses 1 and 2 or 2 and 3.) The design would test two levels of acclimation time (14 days and 60 days) in three tributaries, each with two locations. The proposed experimental tributaries are Rattlesnake Creek, Bumping River, and Little Naches River. This would require 75,000 fish in each of six groups (two treatment levels with three replicates of each) for a total of 450,000 fish.

7.1.3.1 Experimental Hypotheses

7.1.3.1.1 Pre-Facility Hypotheses.

Smolt Out-Migration Survival:

The following pre-facility hypothesis affects all experimental designs that are currently planned for the Yakima Basin. It is related to the important pre-facility study on smolt-to-smolt mortality in the outmigration from the basin.

H_o1: Smolt out-migrant survival is not significantly affected by correctable factors (to be identified).

Alternate hypothesis: Smolt out-migrant survival can be improved by 50% or more.

7.1.3.1.2 Post-Facility Hypotheses.

Post Release Survival:

Post-facility hypotheses dealing with critical uncertainties identified for post-release survival of spring chinook salmon are listed below:

Acclimation Time:

H_o1: There is no difference in survival of fish as a result of length of acclimation.

Alternate hypothesis 1: Longer acclimation time increases survival to outmigrant smolt (at Prosser) by 50% or more.

Alternate hypothesis 2: Longer acclimation time increases survival to returning adult by 50% or more.

H_o2: Smolts released directly into the receiving stream perform as well as fish held in ponds at the release site for a period of 14 days. (The term "perform" alludes to a set of response variables, which together measure supplementation success. The monitoring program being developed is being designed for this purpose.)

Alternate hypothesis: Direct releases perform less than half as well.

H_o3: Smolts held at the release site for 60 days ("extended acclimation") perform as well as those held for only 14 days.

Alternative hypothesis: The extended acclimation period doubles performance.

Homing/Straying Rates:

H_o1: Returning supplementation fish do not stray from their area of release.

Alternate hypothesis: Three percent or more of returning supplementation fish stray from their area of release.

Reproductive Success:

Post-facility hypotheses derived from critical uncertainties relating to the reproductive success of spring chinook are outlined below. Pre-facility work will establish methodologies to track homing and spawning success so that "final" hypotheses can be formulated.

$H_0 2$: H x H reproductive success rates will equal N x N success rate.

Alternate hypothesis: H x H reproductive success rate will be $\leq$50% of N x N rate.

$H_0 3$: H x N reproductive success rate will equal N x N success rate.

Alternate hypothesis: H x N reproductive success rate will be 580% of N x N rate.}

The experimental hypotheses for long-term fitness are contingent on the results of pre-facility studies on genetic sub-stock identification and genetic monitoring.

If high-priority uncertainties relating to spring chinook species interactions are identified during pre-facility studies, appropriate experimental hypotheses and protocols will be developed. None are foreseen at the present time.

7.1.3.2 Exoerimental Protocol

Spring chinook experiments will be conducted in the upper Yakima River (above Roza) and in the Naches River. Experimental acclimation/release ponds will be located in clusters. On the upper Yakima River, there will be three pond sites at each of five geographic clusters for a total of 15 pond sites (Table 7.1). The purpose of geographic clustering is to balance habitat effects among treatment and control groups. On the Naches River, there will be two pond sites at each of three clusters for a total of six spring chinook pond sites. Sites within all clusters will be separated by at least one mile to reduce the likelihood of non-ndependence (.e., of groups within a cluster

TABLE 7.1 Upper Yakima Spring Chinook Experimental Design.

Acclimation Treatment	Number	Replicate Class	Habitat of Fish	Number Site
1	1	I	75,000	Al
2	1	I	75,000	A2
3	1	I	75,000	A3
1	2	I	75,000	B2
2	2	I	75,000	B3
3	2	I	75,000	B1
1	3	I	75,000	c3
2	3	I	75,000	Cl
3	3	I	75,000	c2
1	4	II	75,000	D1
2	4	II	75,000	D2
3	4	II	75,000	D3
1	5	II	75,000	E3
2	5	II	75,000	2
3	5	II	75,000	El
			1,125,000	

NOTE: A through E represent the satellite clusters identified in Chapter 9.0, "Facilities Requirements." Treatment and replicate numbers will be assigned at random among ponds at the central site. Fish will then be moved to release sites, where treatments will be administered, according to the schedule below. Site numbers within a cluster are assigned upstream to downstream such that site 1 is above site 2, etc.

affecting each other) Thus, including control treatments there will be three treatment groups per cluster in the Yakima Basin, and two treatment groups per luster in the Naches Basin. Each treatment will comprise 75,000 smolts, a number based on expected recovery rates and the requirement of 35 recoveries needed for statistical significance (see Section 5.3).

The experimental design in the upper Yakima River has one treatment variable--aclimation strategy. Design is balanced with respect to habitat type (tributary versus mainstem) and relative location (upstream/downstream) of treatments within clusters to control variation. The acclimation release treatments will be tested at three levels. Post-facility Hypotheses 1, 2, and 3, which are in the previous subsection on critical uncertainties for post-release survival, will be tested.

7.1.3.3 Treatment Specifications

For the first level (Acclimation Treatment 1), juveniles will be taken from the hatchery and planted in an acclimation pond (or directly in the river depending on the schedule for construction of ponds) and allowed immediate volitional emigration (if stocked in a pond).

For the control treatment (Acclimation Treatment 2), juveniles would be taken by hatchery truck from the main facility to the acclimation pond site and released into the pond 14 days before the historical mean out-migration from that rearing area. The fish would be fed and restricted from leaving the pond for a period of 14 days. After the 14-day acclimation period, the fish would be allowed a volitional release from the pond.

For Acclimation Treatment 3, juveniles would be treated as in the control, but trucked to the acclimation pond 60 days before outmigration and acclimated for that period.

Acclimation treatments would be assigned randomly within each of two habitat class types. Habitat class would be defined based on factors such as flow, temperature, and/or presence of diversions and screening.

The acclimation facilities for spring chinook and steelhead trout are also being designed to standardize the treatment of final rearing of the release groups. The acclimation facilities have been standardized as 9,000

ft^3 ponds with a density factor of 1.1 (half that of raceways), and a flow of 525 gpm/pond (1.2 cfs/pond). Each pond will be used to finish rearing and acclimate 75,000 spring chinook smolts at 15 per pound, or 25,000 to 33,000 steelhead smolts at 7 per pound. The ponds will be earthen structures with cobble bottoms to simulate natural conditions as much as possible. The ponds will be capable of being totally drained, and most will be gravity fed (the remainder being fed by pump).

There will be three or four clusters of three acclimation sites with the potential for two ponds per site located on the upper Yakima River. In the initial phase of the project only be one pond will be constructed per site. This pond will be for acclimation and release of spring chinook. The option of constructing a second pond at each site accommodates possible acclimation and release of steelhead, should such an option be chosen after analysis and evaluation of pre-facility studies on resident trout/steelhead interactions. Acceptable cluster sites have been identified at the Ellensburg Town Dam, near the main hatchery facility at Cle Elum, and just downstream of the Easton Dam. A cluster site at the Roza Diversion Dam has also been identified but, because it lies downstream of almost all current spring chinook spawning areas, it has been assigned a lower priority.

Tributary cluster sites in the upper Yakima Basin have been identified in the Teanaway River (one mainstem site, two sites in the North Fork, and one potential site in the Middle Fork, which is contingent on the building of an upstream storage reservoir); in the Cle Elum River; and in the section of the Yakima River between Easton Dam and Kechelus Dam. (Based on size and discharge, this reach of the Yakima River was designated a tributary rather than a mainstem reach.)

The Naches River system will have cluster sites on the Bumping River, the Little Naches River, Rattlesnake Creek, and Cowiche Creek. Ponds at these sites will be the same as those described for the upper Yakima River, and each will accommodate either 75,000 spring chinook or 33,000 steelhead.

7.2 YAKIMA SUMMER STEELHEAD

7.2.1 Supplementation Objective

The refined goal is to increase the adult steelhead production potential in the Yakima Basin by about 65% from the current level, while preserving the genetically unique stock in Satus Creek. It is currently anticipated that smolt outplants of 400,000 will achieve this goal. Under existing conditions of habitat quality and quantity, and excluding the portion of the basin above Roza Dam, outplants are expected to comprise about 64% of the total adult return to the basin. A supplemented fishery managed for MSY to all fisheries is estimated to generate a total run size of 11,973. This would result in a run size to the mouth of the Yakima River of 6,831. These figures were estimated by the Council's System Planning Model, and incorporate the best available estimates of carrying capacity, survival, and other population parameters.

The projected MSY run size to Satus Creek under supplementation requires some explanation. Satus Creek steelhead under YKPP management are analogous to American River spring chinook: unsupplemented, yet harvested at overall MSY rates. As is the case with American River spring chinook, the higher terminal harvest rates associated with increased supplementation success will cause the abundance of the Satus Creek stock to fall. However, the inverse relationship between Satus Creek stock status and supplementation success is not as dramatic as it is for American River spring chinook. This is because, in contrast to American River spring chinook, the Satus Creek stock rears below most known areas of heavy smolt mortality. Moreover, approximately half of the Satus fish smolt at age 1, while almost all Naches/upper Yakima River steelhead smolt at age 2 or age 3; egg-to-smolt survival rates in the Satus Creek system are therefore over 50% higher than in the upper basin. As a consequence of these factors, MSY stock status in Satus Creek does not fall below 50% of "baseline" (MSY escapement under existing conditions without supplementation) until supplementation success exceeds 60%. Moreover, if the previously-mentioned projects intended to increase in-basin smolt survival (see spring chinook section) are successfully implemented, MSY stock status for Satus Creek steelhead will be over 90% of baseline at 60% supplementation success.

The final point to discuss in connection with steelhead supplementation goals concerns the exclusion of habitat above Roza Dam from the simulation. Exclusion of habitat above Roza may be reasonable only in the short term. Half of the potential steelhead production area in the basin is above Roza Dam. The fishway at the dam has been fully functional since 1987, and steelhead spawners are in fact being counted over the dam at the present time. If this voluntary colonization continues, the expected benefits of the YKPP steelhead program may actually be substantially greater than 65% over baseline. Explicitly, if habitat above Roza Dam is added to the simulation, supplemented total run and Yakima escapement are 70% higher than the (supplemented) scenario with above-Roza habitat excluded. Note, however, that there is no intention of releasing YKPP steelhead smolts above Roza Dam prior to 1995 except as approved at the policy level for rainbow/steelhead interaction studies. Steelhead supplementation above Roza Dam after 1995 will rest on a policy-level decision informed by the results of interaction studies.

The Yakima River Basin presents a unique opportunity for experimentation with steelhead. There are three potential production areas in the basin: Satus/Toppenish Creeks, the Naches River, and the upper Yakima River. As Satus Creek has never been supplemented with hatchery fish, it is believed that the steelhead there represent essentially native fish. The steelhead in the Naches system have been supplemented with hatchery fish of various stocks for many years. The upper Yakima River was historically supplemented with various hatchery stocks, but this area now supports only a vestigial run. Thus, the potential exists to plan experiments that test genetic impacts as well as the feasibility of re-populating severely underutilized areas. The upper Yakima River will be used to study the interaction of anadromous steelhead and resident trout in selected reaches.

7.2.1.1 Assumptions

With one exception, the assumptions underlying the supplementation objective for steelhead are identical to those for spring chinook (see Section 7.1.1). The exception is that habitat above Roza Dam is not used by steelhead.

7.2.2 Critical Uncertainties

7.2.2.1 Post-Release Survival

The critical uncertainty for smolt size and age at release is similar but more complex for steelhead than that described for Yakima River spring chinook. Current information suggests that Yakima steelhead out-migrants are about evenly divided between 1 and 2 years of fresh water rearing. Supplementation steelhead will be reared in the hatchery for 1 year and then out-planted into ponds on targeted streams.

A means to monitor juvenile steelhead not ready to smoltify after lyear through their second year of freshwater res idence is desired in order to determine their contribution to adult returns. Another uncertainty is the effect on genetic variability of rearing all the supplementation steelhead only 1 year.

7.2.2.1.1 Pre-Facilitv Needs. Preliminary studies indicate that mortality may exceed 60% for natural steelhead smolts during their emigration from upper basins to Prosser. Further studies need to be conducted to determine precise, reach-specific survival rates as well as the causes of mortality in specific reaches.

This critical uncertainty of post-release survival is a pre-facility need that must be resolved better understood the production facility is on line. Studies are currently being designed to refine the mortality estimates and identify sources of mortality in order to improve outmigration survival rates. Improved understanding of in-basin (Yakima River) smolt survival will suggest measures that could improve survival of all smolts and accelerate the rebuilding process.

Another important pre-facility need is the development and calibration of smolt and adult monitoring facilities as described in Chapter 9.0, "Facilities Requirements."

In addition to the high mortality experienced by naturally produced smolts, hatchery-reared smolts are subject to an additional post-release mortality thought to be caused by a lack of "conditioning" to the natural environment. At this time, the effects of acclimation and release strategy on post-release survival of hatchery reared fish are not fully understood. Physiological recovery from the stress of transport and, perhaps, the acquisition of adaptive patterns of behavior (e.g., predator avoidance and natural feeding behavior), are two possible mechanisms which could enhance the survival of acclimated smolts. Whatever the mechanism, it is hypothesized that acclimation will reduce the post-release mortality usually experienced by outplanted hatchery fish, and that this will result in greater survival to adulthood. Recent studies of spring chinook in the Yakima basin indicate that smolts released volitionally from acclimation facilities have a higher survival rate, to the Prosser smolt counting facility and to returning adult, than do fish released directly into the river (Fast et. al. 1986).

Experience throughout the region demonstrates the importance of broodstock selection and low density rearing in fish culture. The major untested uncertainties involve strategies for introducing fish into the natural environment in a manner that will maximize survival. These tests are a key to the experimental design of the operational phase of the project.

7.2.2.2 Reproductive Success

See Yakima Spring chinook Section 7.1.2.

7.2.2.2.1 Pre-Facilitv and Post-Facility Needs

7.2.2.3 Lonq-Term Fitness

The Yakima River steelhead represents the second greatest genetic concern in the two basins. Hatchery stocking has not occurred in the Satus Creek system and has been relatively unsuccessful in the past in the Naches Basin. For this reason, many of the critical questions concerning steelhead involve the genetic effect of using hatchery-reared "native" stock to supplement the natural production in the basin. Other critical uncertainties exist regarding the re-introduction of steelhead stocks into areas that currently have no steelhead production or are severely underseeded, and what effect this reintroduction or supplementation would have on the current levels of production of resident trout populations. Experiments will be designed to evaluate the survival of supplementation fish produced for supplementation. These studies will focus on egg-to-smolt and smolt-to-adult survival of the offspring of supplementation fish in successive generations. Critical uncertainties and hypotheses relating to survival and genetics are formulated for the two areas of concern--broodstock selection, and rearing and release strategies.

Issues related to broodstock selection are even more critical for the steelhead of the various sub-basins of the Yakima River than for spring chinook. Steelhead are known to spawn in several of the smaller tributaries of the Yakima River and are therefore more likely to have small discrete sub-populations with effective spawning sizes of less than 1,000 adults. This will necessitate development of methods to allow supplementation of these populations without negatively affecting their genetic makeup. Current guidelines suggest using at least 100 adult males and 100 females as broodstock. An upper limit of 20%.of any naturally returning run as broodstock was established for this project to insure that there will be adequate escapement and spawning to naturally perpetuate the gene pool. This two hundred adults at 20% of the spawning population will necessitate a sub-stock population of at least 1,000 fish before we could take any of the adults as broodstock under this scenario.

7.2.2.3.1 Pre-Facilitv Needs

The WDF is conducting pre-facility research that will provide information on the number and distribution of genetically distinct sub-stocks in the basin. The results will be important in final selection of broodstock practices as described above.

7.2.2.4 Species Interactions

The potential for interaction between anadromous steelhead and resident rainbow trout has been identified as a critical uncertainty in the long-term success of steelhead supplementation in the Yakima River above Roza Dam.

7.2.2.4.1 Pre-Facilitv Needs

Pre-facility studies are being conducted to collect baseline data on resident trout populations in this area. There is also a need to determine the potential for intra-specific interactions, particularly as regards movement of hatchery from tributaries to the mainstem in the winter months.

EDWG will design experiments to monitor and evaluate the effect of steelhead supplementation on these populations of resident trout.

7.2.3 Experimental Desian

7.2.3.1 Experimental Hvpotheses

7.2.3.1.1 Pre-Facilitv Hvootheses

As stated in the spring chinook section, the most important pre-facility hypothesis related to smolt survival are:

Outmiaration Survival:

H_o1: Smolt out-migrant survival is not significantly affected by correctable factors (to be identified).

Alternate hypothesis: Smolt out-migrant survival can be improved by 50% or more.

7.2.3.1.2 Post-Facility Hvpotheses. The experimental design for a smolt survival study is being developed by EDWG for implementation as a pre-facility study. If hatchery smolts do not have as high a survival rate as expected, the following post-facility hypotheses relating to post-release survival would be tested:

Aqe and size at release:

H_o1: Hatchery smolts that are the same age and size as wild smolts will survive at the same rate as larger (size to be specified) hatchery smolts.

Alternate hypothesis: One of the two groups will survive twice as well as the other.

Size and Time of Release:

There is uncertainty about the most efficient size and time of release for out-planting steelhead. Smolt releases are most common and are the designated control treatment. The following hypotheses will be tested:

H_o1: There is no difference in survival (from egg to returning adult) in the first generation between the "best" smolt release strategy and the "best" fry release strategy.

Alternate hypothesis: The "best" smolt release strategy produces an egg-to-adult survival that is at least 50% greater than that produced by the "best" fry release strategy.

$H_0 2$: There is no difference in survival over the first two generations (from eggs in the first hatchery generation to the return of their offspring as naturally produced adults) between the "best" smolt release strategy and the "best" fry release strategy.

Alternate hypothesis: Fry releases survive at least twice as well over two generations.

Release Strategies:

The uncertainties for the effect of release strategy on post-release survival of steelhead are also similar to those described above for Yakima River spring chinook. The hypotheses to be tested are:

$H_0 1$: There is no difference in survival of fish to returning adult or (outmigrant smolt) as a result of release technique.

Alternate hypothesis 1: Longer acclimation time increases survival to outmigrant smolt (at Prosser) by 50% or more.

Alternate hypothesis 2: Longer acclimation time increases survival to returning adult by 50% or more.

(Two alternates are specified above, since different marking methods may be used in tests against the two alternates, perhaps CWT against Alternate 1 and PIT tags against Alternate 2. Determination of the most effective marking method for each experimental purpose is an identified pre-facility need which is currently being addressed. The same experiment may also be used to test whether there is a difference in survival from Prosser to adult as a result of release technique.)

$H_0 2$: Smolts released directly into the receiving stream perform as well as fish held in ponds at the release site for a period of 14 days. Note that the term "perform" alludes to a set of response variables, which together measure supplementation success. The monitoring program being developed is being designed for this purpose. The variable hypothesized to respond to these treatments is post release survival.

Alternate hypothesis: Direct releases perform less than half as well.

H_o3: Smolts held at the release site for 60 days perform as well as those held for only 14 days.

Alternative hypothesis: The extended acclimation period doubles performance.

Recent studies indicate that extended acclimation times, (i.e., 60 days) improve survival, but this remains untested for steelhead in the Yakima River. Therefore, specifications for control and test treatments are being developed to test the following hypotheses:

H_o1: There is no significant difference in survival of fish through time between (extended) acclimated fish and non-acclimated fish (more detailed specification of response variables and treatments will be provided in the future).

Alternate hypothesis: Fish undergoing extended acclimation survive 50% better than non-acclimated fish.

H_o2: If acclimation is effective, then: Short-term acclimation is as effective as extended acclimation.

Alternate hypothesis: Extended acclimation will increase survival by at least 50% over short-term acclimation.

Homing/Straying Rates:

H_o1: Supplementation fish do not stray.

Alternate hypothesis: At least 3% of returning supplementation fish stray from their release area.

Reproductive Success:

Reproductive success hypotheses are contingent upon completion of pre-facility studies (defining and testing response variables) on reproductive success. However, several general hypotheses can be forwarded at the present time:

H_o2: H x H reproductive success rates will equal N x N success rate.

Alternate hypothesis: H x H reproductive success rate will be $\leq 50\%$ of N x N rate.

H_o3: H x N reproductive success rate will equal N x N success rate.

Alternate hypothesis: H x N reproductive success rate will be $\leq 80\%$ of N x N rate.

Hypotheses related to long-term fitness will ultimately depend on the outcome of the WDF pre-facility genetic sub-stock identification and monitoring program. Several potential hypotheses related to current knowledge of genetic structure of Yakima River steelhead will be included. The current belief is that stocks most similar to supplemented stock or from similar habitat should be utilized for supplementation. To test this belief, stocks similar to the control or standard will be used and the following hypotheses will be tested:

H_o1: There is no difference in long-term survival (from first generation hatchery eggs to second generation natural adult offspring) between genetically-specialized (Satus Creek) and genetically-mixed (Naches River) stocks.

Alternate hypothesis: Genetically-specialized (Satus Creek) stocks will have a 100% higher long-term survival than genetically-mixed stocks when supplemented in streams similar to those of origin.

The following response variables will be measured:

- Survival to first generation adult (from eggs entering the Yakima Basin to marked adults returning).
- Survival through several generations (techniques for marking and monitoring second generation survival will be developed as part of a study requested by the EDWG).

The hypotheses for the interaction critical uncertainties will be developed during the WDW species interaction pre-facility study.

7.2.3.2 Experimental Protocol

The experimental design is constricted by the production capacity of 400,000 for steelhead in the Yakima River. A minimum experimental group size has been established at 25,000 to 33,000 smolts to produce an estimated 35 adult recoveries per group (see Section 5.3). Twelve groups of 25,000 to 33,000 smolts could be divided into three replicates each of four broodstocks or six replicates each of two broodstocks.

An example of an experimental design to test the effects of stock selection would be to release l-year fish at 7 per pound from volitional acclimation ponds. Three tributary release sites are anticipated. The treatment would be tested at two levels of stock selection including the control.

7.2.3.3 Treatment Specifications

Summer steelhead adults will be collected at Cowiche Diversion Dam, and as required for other selected sub-stocks, and spawned at the Nelson Springs main facility. The egg incubation and early rearing will occur at the Nelson Springs facility. The final rearing will be split between the Nelson Springs and Oak Flats sites with 50% of the juveniles at each main facility.

The resultant 400,000 pre-smolts will then be transported to six acclimation facilities on the Naches River system (200,000 fish), three acclimation facilities on the Toppenish Creek system (100,000 fish), and three acclimation facilities tentatively scheduled for interaction research experiments on the upper Yakima River (100,000 fish). The Naches Creek system will have acclimation sites located on the Bumping River, the Little Naches River, the Rattlesnake Creek, and the Cowiche Creek. These sites will be the same as those described for the upper Yakima River with ponds at each site for 75,000 spring chinook and 33,000 steelhead smolts. A maximum of three sites will also be developed on the Toppenish Creek system for steelhead releases.

All of the sites that are currently being considered for acclimation and release ponds in the various reaches of the Yakima Basin are identified in Chapter 9.0 (Table 9.1). This table also includes the species, numbers of fish released, size at release, and date of release.

7.3 YAKIMA BASIN FALL CHINOOK

7.3.1 Supplementation Objective

The goal is to increase the adult fall chinook production in the Yakima Basin by about 95% from the current level. It is currently anticipated that smolt out-plants of 3,600,000 will achieve this goal. Under existing conditions of habitat quality and quantity, out-plants are expected to comprise about 50% of the total adult return to the basin. A supplemented stock managed for MSY to all fisheries is expected to generate a total run size (including ocean harvest) of 35,700, and a run size to the mouth of the Yakima River of 6,400, as estimated by the Council's System Planning Model.

7.3.1.1 Assumotions

The supplementation goal for Yakima fall chinook entails a set of assumptions similar to those made for spring chinook with the exception that the post-release survival of hatchery fish was assumed to be equal to natural fish. In addition the in-basin smolt-to-smelt survival of hatchery fish is expected to be approximately 80% that of natural smolts. This expectation exists because proportionately more hatchery fish will be released higher in the drainage, in reaches where smolt mortality is high, whereas about 70% of natural production is expected to occur below Prosser Dam, where smolt mortality may be relatively lower.

As mentioned, hatchery fish will comprise about half the return in a fishery supplemented by 3.6 million smolts and managed at MSY. The proportion of hatchery fish during initial years of the program will likely be higher than 50% of the run because current natural production is far below estimated (unsupplemented) MSY levels. Genetic risks have not been identified as a primary concern of the YKPP because fall chinook have been routinely supplemented with non-native hatchery out-plants. However, small locally adapted populations do exist in the lower Yakima River mainstem and in Marion Drain, a perennial irrigation return 36 miles above Prosser Dam. To maximize supplementation success, "in-basin" spawners will be the preferred source for hatchery broodstock. Planning efforts have already begun to use local broodstock for the basin's current fall chinook production program.

7.3.2 Critical Uncertainties

7.3.2.1 Post-release Survival

Preliminary results from recent fall chinook coded-wire tag (CWT) releases within the Yakima River, which represent a variety of rearing and release strategies, have demonstrated catch per fish released values ranging from 0 to about 4%. These variable results suggest that effects of different strategies for trucking, acclimation, and release are critical uncertainties with respect to achieving consistent post-release survival rates even at intermediate success levels (e.g., 50% of natural smolt-to-adult survival).

Another factor affecting post-release survival is in-river smolt mortality during emigration (smolt-to-smolt mortality). Low smolt survivals of spring chinook and steelhead have been estimated during emigration to Prosser Dam. The magnitude and variability of fall chinook smolt-to-smolt mortality is currently unknown. Survival conditions below Prosser Dam, where a large proportion of total fall chinook production potential is expected to occur, are likely a significant post-release factor. The effects of different rearing and release strategies on the smolt-to-smolt component of post-release survival is a critical uncertainty affecting supplementation success. In addition the causes of smolt-to-smolt mortality, if identified and understood, might be effectively managed in concert with the experimental production strategies of the YKPP to maximize project benefits.

7.3.2.1.1 Pre-Facility Needs. Several pre-facility needs exist to allow evaluation of these critical uncertainties (i.e., testing effects of post-facility rearing and release strategies on post-release survival). These needs are highlighted below.

1. Rearing and release strategies need to be developed that expand flexibility to test experimental options which may maximize post-release survival of fall chinook smolts. Short-term rearing feasibility, via net pens, is currently being evaluated for fall chinook. Net-pen production capacity now is about 0.4 million smolts reared and released at the Wapato Diversion Canal. An additional 1.6 million fa11 chinook are being released as direct off-stat ion plants from other Columbia River hatcheries as part of the United States versus

Oregon management plan. This production provides opportunity to begin evaluating the level and annual variability of smolt-to-adult survival. Potential for using current rearing capabilities to evaluate impacts of experimental variables (e.g., acclimation) should be explored.

Acclimation should be used as a treatment variable during pre-facility evaluation studies to the extent that current production capabilities allow. The potential use of net pens to acclimate releases and maximize survival is a pre-facility question of particular importance since it could provide considerable flexibility for facility implementation.

2. Levels, sources, and seasonal/annual variability of Yakima Basin smolt-to-smolt mortality need to be determined. Current evidence strongly indicates that unusually high and disproportionate smolt losses occur in specific reaches. A study plan should be developed and implemented to answer these questions and recommend strategies to improve post-release survival of fall chinook and other species under the YKPP. This mortality problem also creates uncertainty about natural reproductive success, especially since the entire juvenile rearing and emigration phase for fall chinook occurs under potentially deleterious conditions. The use of current fall chinook plants to answer smolt mortality questions should be a priority if needed under the study plan.

7.3.2.2 Reproductive Success

Strategies of acclimation (or trucking/direct release) and release sites represent critical uncertainties with respect to meeting underlying assumptions about reproductive success (i.e. the primary assumption of achieving adequate spatial distribution of spawners returning from hatchery plants). If returning adults do not fully take advantage of available spawning habitat, then natural production potential cannot be achieved.

Beyond spatial distribution of spawners, the comparative reproductive success (i.e., offspring per spawner estimated at various life history stages) of hatchery-origin versus natural-origin adults likely will be difficult to measure quantifiably due to the logistical challenge of sampling lower mainstem areas. The general goal of increasing the population to expected MSY levels, however, can be evaluated through measurement of total smolt outmigration and adult return estimates coupled with estimates of hatchery proportions in the population. Initially, increasing levels of total adult returns should produce increased natural smolt and adult production for the brood. The uncertainty of smolt-to-smolt mortality obviously may affect this expectation.

Another uncertainty affecting reproductive success could be change in maturation rates and age-at-return resulting from rearing practices. Current production plans call for release of fall chinook smolts at 65 per pound, which is considerably larger than natural smolts, in order to maximize post-release survival. If this accelerated release size significantly reduces average age-at-return, increased smolt-to-adult survival could be moderated by decreased reproductive success of the next generation (e.g., reduced average fecundity and reduced redd building effectiveness). Further work, which is identified below, is required to determine whether this is a critical uncertainty.

7.3.2.2.1 Pre-Facility Needs. Several pre-facility needs exist to allow evaluation of uncertainties that impact achieving assumptions regarding reproductive success. These are highlighted below.

1. Adult monitorina methodologies, including cost-effective juvenile marking approaches, need to be developed in order to estimate proportions of hatchery returns (by release group) in various lower river soawnina areas. This measurement capability is critical for comparing the spatial distribution of spawners from different release strategies. Adult monitoring approaches do not exist for fall chinook below Prosser Dam where a majority of spawning activity is expected. All hatchery fish may need to be marked to allow statistically significant comparisons of this response variable. The optimum juvenile marking method needs to be identified.

2. Adult escapement and smolt out-migration estimation methodolooies need to be developed for fall chinook. Production estimates, and the ability to separate hatchery versus natural components, will be central to the general assessment of reproductive success identified above.

3. The potential impact of accelerated rearinq on female reoroductive potential needs to be assessed with respect to meetina project assumptions about reoroductive success. Potential changes in age structure, which likely will occur from accelerated rearing, may or may not be critical to reproductive success and long-term fitness of subsequent generations. Simulation analysis with the existing sub-basin life history model should provide needed insight to this question. Returns from recent pen releases should indicate the magnitude of reduction in age-at-spawning. Significant changes in maturity rates and ocean exploitation also would limit application of hatchery tag groups to estimate adult recruitment for naturally reproducing fish, perhaps requiring an alternate index. Basic age and fecundity characteristics of natural fall chinook stocks in the Yakima River will be needed to assess these potential changes.

7.3.2.3 Lens-Term Fitness

The impact of the supplementation program on the long-term productive capacity of Yakima River fall chinook has not been considered a critical uncertainty because of the status of the existing population (i.e., at low levels and already heavily supplemented). In this case it may be more appropriate to evaluate long-term fitness not to an existing standard but to an "ideal" potential that an unsupplemented population might otherwise achieve if rebuilt naturally. The production program assumes use of locally adapted stocks to maximize long-term natural production potential. This raises the question whether unique population resources may currently exist in the basin, The potential need exists to complement adult and juvenile production monitoring (see the Section 7.3.2.2, "Reproductive Success") with some monitoring of population characteristics, although perhaps not as intensively as for spring chinook and steelhead in the Yakima Basin.

7.3.2.3.1 Pre-Facility Needs. Two pre-facility needs exist to allow definition of post-facility hypotheses and experimental priorities for questions regarding long-term fitness.

1. Develop local upriver brisht brood stock for the hatchery proqram. Genetic and biological characteristics (potentially including habitat

use and basic life history) of existing fall chinook populations in the Yakima Basin need to be defined in order to assist planning of future hatchery broodstock collection.

2. Genetic monitorina and evaluation plans need to be developed for facility imolementation. Although the priority of this need is higher for spring chinook and steelhead, it represents a component of a comprehensive genetics evaluation program.

7.3.2.4 Species Interactions

The underlying assumption about no significant intra-species interactions between hatchery and natural fall chinook juveniles in lower river rearing areas was founded on the concept that rearing and release strategies could be managed to avoid competition. For example, by achieving hatchery smolt migration readiness, the opportunity for interaction would be minimized. The effects of hatchery release time and smolt size, however, may represent critical uncertainties with respect to avoiding competition. The transit time of hatchery smolts through the lower river and their migration timing compared with natural fish define the degree of potential overlap. To the extent overlap occurs, the differentially larger size of hatchery fish would tend to give them a competitive advantage over their natural counterparts.

7.3.2.4.1 Pre-Facility Needs. A pre-facility need exists to evaluate and prioritize uncertainties for the experimental program relating to definition of juvenile migration characteristics (migration timing, transit time, and fish size) for both hatchery and natural fall chinook. The potential for interaction and the possible impact of alternative rearing and release strategies on species interactions need to be assessed.

7.3.3 Experimental Desian

7.3.3.1 Experimental Hypotheses

Fall chinook supplementation hypotheses are all subject to a performance challenge of post-release, smolt-to-adult survival equalling 1%. Below this assumption, the following pre-facility hypotheses exist for strategies affecting post-release survival:

7.3.3.1.1 Pre-Facility Hypotheses.

H_o1: Fall chinook smolts directly released into the lower Yakima River survive as well as smolts held in (and released from) net pens at release site for 60 days.

Alternate hypothesis: Direct releases survive only half as well as net pen releases.

Measured response variables include smolt-to-smelt and smolt-to-adult survival. The former measure will require development of smolt monitoring capabilities near the mouth of the Yakima River.

Additional post-facility hypotheses regarding strategies affecting post-release survival will be developed and refined once information on net pen feasibility and smolt-to-smolt mortality is obtained from pre-facility studies.

7.3.3.1.2 Post-Facility Hypotheses. A number of post-facility hypotheses have been framed dealing with critical uncertainties identified above for reproductive success, relating to the assumption of wide distribution of hatchery returns in natural spawning habitat. The experimental strategies involved that affect achieving this assumption are acclimation versus trucking/direct release and release site (in relationship to spawning areas). It appears quite likely that these experiments also could serve to directly test companion hypotheses dealing with post-release survival and species interaction population response areas; for example, where measures of spawning distribution could be replaced by smolt-to-adult survival as the response variable.

H_o2: Adult returns from acclimated releases from Wapato pens disperse as widely as acclimated releases from Wapato raceways.

Alternate hypothesis: Adult returns from acclimated net pen releases disperse half as widely as acclimated releases from Wapato raceways.

H_o3: Adult returns from trucked, non-acclimated releases at Wapato disperse as widely as acclimated releases from Wapato raceways.

Alternate hypothesis: Adult returns from trucked, non-acclimated releases at Wapato disperse twice as widely as acclimated releases from Wapato raceways.

$H_0$4: Adult returns from acclimated releases at Prosser raceways disperse as widely as acclimated releases from Wapato raceways.

Alternative hypothesis: Adult returns from acclimated releases at Prosser raceways disperse twice as widely as acclimated releases from Wapato raceways.

$H_0$5: Adult returns from acclimated net pen releases at Horn Rapids disperse as widely as acclimated releases from Wapato raceways.

Alternate hypothesis: Adult returns from acclimated net pen releases at Horn Rapids disperse twice as widely as acclimated releases from Wapato raceways.

$H_0$6: Adult returns from trucked/direct releases below Horn Rapids disperse as widely as returns from acclimated releases from Wapato raceways.

Alternate hypothesis: Adult returns from trucked/direct releases below Horn Rapids disperse twice as widely as acclimated releases from Wapato raceways.

"Final" post-facility experimental hypotheses to resolve uncertainties impacting post-release survival, reproductive success, and long-term fitness will be formulated based on results of pre-facility studies. Pre-facility studies to develop lower river monitoring capabilities also will indicate whether the underlying assumption regarding no intra-species interactions impacts is reasonable or, alternatively, whether specific hypothesis testing is warranted.

7.3.3.2 Experimental Protocol

The current production plan for fall chinook anticipates 18 raceways of 200,000 fish to be reared to an average 65 fish per pound (7 g, 95 mm) for release. Six of these raceways will be sited near Prosser Dam and 12 will be sited near Wapato Dam. Ongoing net-pen feasibility studies, if successful, could translate into additional rearing and release flexibility in the experimental program, although production numbers for this option could be limited by sites and space. Protocol identified below only reflect the current status of pre-facility planning. Additional planning is needed with respect to reproductive success, long-term fitness, and species interactions as discussed above.

The effects of release site and acclimation on post-release survival and adult spawning distribution (component of reproductive success) are the highest priority uncertainties at this time. Releases at points below Prosser Dam could bypass in-river smolt mortality problems, but potential improvements in post-release survival could be counteracted by stress of direct (non-acclimated) releases and reduction of reproductive success (sub-optimal distribution of spawners throughout available habitat).

The standard/control for these tests would be the acclimated, onsite releases from Wapato raceways (3 replicates). The treatments would be as follows (5 treatments with 3 replicates each):

- acclimated release from Wapato pens
- trucked, onsite release at Wapato
- acclimated, on-site release at Prosser Dam
- trucked, direct release near Horn Rapids
- acclimated release from net pens near Horn Rapids

Response variables for post-release survival may include per-group out-migration numbers/survival rates past the Richland monitoring station; per-group marine and mainstem Columbia harvest; and per-group estimated escapement (subject to adequate methodology being developed).

Response variables for the spawning distribution component of reproductive success may include per-group dispersion across available spawning sites (e.g., area-reach adult spawners/total adult spawners or proportion above and below Prosser).

7.3.3.3 Treatment Specifications

No treatment specifications beyond the general guidelines discussed in Chapter 4.0, "Hatchery Operation Standards and Assumptions," have been outlined. Expected refinements of the hypotheses that will result from pre-facility studies make this step premature at this time.

7.4 YAKIMA BASIN SUMMER CHINOOK

7.4.1 Supplementation Objective

The principal goal of the summer chinook program is to re-introduce the stock into the basin. However, preliminary estimates suggest that if a naturally reproducing population were re-established by the proposed outplanting of 156,000 smolts per year, the total run size (including ocean harvest) at MSY would amount to about 6,000 fish, and the run size to the mouth of the Yakima River would be about 3,200. These figures assume existing habitat quantity and quality. As the hatchery contribution to the total run would only be about 10%, total surplus production could be increased significantly if more than 156,000 smolts were released per year. These figures were estimated by the Council's System Planning Model.

7.4.1.1 Assumptions

The supplementation goal for Yakima River summer chinook entails all of the spring chinook assumptions. In addition, three assumptions unique to summer chinook were made, two of which were necessitated by the fact that summer chinook are extinct in the basin. The first was to assume that natural summer chinook have the same smolt survival rates as natural fall chinook. The second assumption was that hatchery summer chinook have the same smolt survival rates as Naches River hatchery spring chinook.

7.4.2 Critical Uncertainties

7.4.2.1 Post-Release Survival

The effects of hatchery rearing and release strategies on smolt-to-adult survival are a lower priority critical uncertainty in the goal to re-establish a natural spawning run since adverse habitat and water quality conditions noted below are severe.

No pre-facility needs or hypotheses have been identified because release numbers would not permit rigorous experimentation, and questions regarding natural reproductive success are over-riding.

7.4.2.2 Reproductive Success

The central uncertainty to re-establishing summer chinook in the Yakima are adverse temperature, flow, and water quality conditions during summer juvenile rearing/emigration and adult entry. These uncertainties would appear to severely limit achievement of the supplementation goal and have delayed production planning for the stock.

No pre-facility needs or hypotheses have been identified since uncertainties do not relate to hatchery production strategies.

7.4.2.3 Long-Term Fitness

Uncertainties affecting long-term fitness have not been considered a priority concern since no populations currently exist in the basin and the feasibility of re-establishing viable, naturally spawning populations has not been determined.

No pre-facility needs have yet been identified. They will be determined after feasibility questions discussed above have been resolved.

7.4.2.4 Species Interactions

If summer chinook were reestablished in the Yakima, adult spawning generally would be expected in the area from Yakima to Roza Dam and in the Lower Naches system. The potential would exist, even within this limited area, for spawning overlap (interbreeding) with natural spring chinook stocks. This question also could have implications for hatchery broodstock collection depending on location.

7.4.2.4.1 Pre-Facility Needs. A pre-facility need exists to assess this genetic risk and recommend hatchery production alternatives to avoid it (see Section 3.3).

7.4.3 Experimental Design

No specific experimental design has been developed for summer chinook because of the limited production planned and the overwhelming uncertainties of non-supplementation factors in meeting project objectives.

7.5 YAKIMA BASIN COHO

7.5.1 Supplementation Goal

The principal goal of the coho program is to create an additional terminal area fall harvest opportunity from a production and management plan that maximizes harvest of hatchery fish. Preliminary estimates suggest that a supplemented fishery managed at MSY for hatchery fish would generate a total run size (including ocean harvest) of 18,800 and a run size to the mouth of the Yakima River of 2,900. Hatchery fish would make up over 99% of the return. It is anticipated that smolt releases of 2.6 million will achieve this level of production. These figures were estimated by the Council's System Planning Model.

To reiterate, the primary purpose of the coho program is to produce a large surplus production to treaty and non-treaty fishers. Under existing fishery regimes, maximum sustained yield to all fisheries (ocean, Columbia mainstem and terminal) would be about 14,400 fish. However, this harvest would occur almost exclusively below Bonneville Dam, in the ocean, and in the Columbia estuary. Harvest opportunity increases by 90% to all fisheries when projected improvements in-basin smolt survival are incorporated into the model.

7.5.1.1 Assumptions

There are no longer endemic coho stocks in the Yakima Basin. The supplementation goal for Yakima river coho entails many of the same assumptions made for spring chinook, and some species-specific assumptions. The hypothetical natural Yakima coho population modeled has a species-specific egg-to-smolt survival rate, distribution, and carrying capacity, but an in-basin smolt survival rate borrowed from spring chinook. The in-basin smolt survival rate of hatchery coho smolts was assumed to be 86% of the "natural" rate based on available data. Note that genetic risks are not considered critical as coho (non-native) have only recently begun to return to the basin. However, use of returning adults for broodstock would probably select for locally-adapted fish, thus increasing post-release survival.

7.5.2 Critical Uncertainties

7.5.2.1 Post-release Survival

Recent releases of coho smolts in the basin have survived poorly although factors such as fish health are known to have contributed. Returns in 1989 have been more promising. Effects of hatchery rearing and release strategies on post-release survival is the overriding critical uncertainty affecting achievement of the supplementation objective. Use of locally adapted broodstock and acclimated releases are strategies considered important for maximizing success.

Smolt-to-smolt mortality is also a critical uncertainty with respect to coho. Poor survival conditions during out-migration will directly impact post-release survival.

7.5.2.1.1 Pre-Facility Needs. Two pre-facility need exist to refine the experimental plan and assist facility implementation objectives: 1) to determine levels, sources and variability of Yakima Basin smolt-to-smolt mortality (see Section 7.3.2); and 2) develop coho broodstock for the hatchery program. No other pre-facility needs have been identified for coho, although current releases of hatchery coho via the United States versus Oregon agreement could present opportunities to begin experimentation before the new facilities are constructed.

7.5.2.2 Reproductive Success

No primary supplementation objectives exist for maintaining naturally spawning populations for coho. However, an objective exists to study the feasibility of reintroduction and maintenance of naturally spawning runs. Effects of hatchery rearing and release strategies are critical uncertainties with respect to evaluating questions of reproductive success of hatchery adult returns (see previous section). Therefore, no uncertainties currently have been identified that affect reproductive success.

7.5.2.2.1 Pre-Facility Needs. A pre-facility need exists to defined the objective of a study to determine the feasibility of reintroducing naturally reproducing coho runs.

7.5.2.3 Long-Term Fitness

No assumptions regarding long-term fitness are central to meeting the project's coho production objectives.

7.5.2.4 Species Interactions

Species interactions have not been considered a concern for the coho program because of the overriding question of post-release survival success and the high harvest rate intent. The effect of release strategies (i.e., smolt migration readiness) on potential interactions with lower river fall chinook needs to be considered in operations planning, however, no pre-facility needs are anticipated.

7.5.3 Experimental Desian

7.5.3.1 Exoerimental Hypotheses

7.5.3.1.1 Pre-Facility Hypotheses. No pre-facility experiments are contemplated.

7.5.3.1.2 Post-Facility Hypotheses. Post-facility hypotheses identified to date would test the effects of different acclimation strategies on post-release survival. Acclimation in this case actually represents conditioning fish at a central facility to the adjacent river release environment.

H_o1: Smolts directly stream planted will survive as well as fish acclimated and released at same site for 14 days.

Alternate hypothesis: Direct stream plants will survive only half the rate of those acclimated.

H_o2: Smolts acclimated for 7 days will survive as well as smolts acclimated for 14 days.

Alternate hypothesis: Smolts acclimated for 7 days will survive only half as well as smolts acclimated for 14 days.

Beyond these hypotheses, additional questions will be developed to determine the feasibility of re-introducing natural runs of coho.

Because of the more standard hatchery nature of the proposed coho program, hatchery culture techniques likely represent the second priority level for treatment variables.

7.5.3.2 Experimental Protocol

The current production plan for coho anticipates 6 raceways of 75,000 fish each at Oak Flats and 3 large ponds containing slightly more than 0.5 million each at Wapato. No provisions currently exist for off-site, acclimated releases. The Oak Flats production would likely be a source of research fish for the natural coho feasibility study, once defined.

7.5.3.3 Treatment Specifications

No treatment specification have been developed at this stage of the experimental design planning process.

7.6 YAKIMA BASIN SOCKEYE

7.6.1 Supplementation Objective

Sockeye runs existed in the Yakima Basin historically, but now only kokanee reside in several of the basin's irrigation reservoirs.

The supplementation objective for sockeye will depend on the results of a current study being conducted in Lake Cle Elum to determine the feasibility of establishing a self-sustaining anadromous sockeye run in the Cle Elum River watershed.

7.6.1.1 Assumptions

No risk to an existing anadromous sockeye gene pool is expected from this program. Any stock to be established in the Yakima River system would have to be capable of avoiding summer water quality problems in the lower Yakima River (e.g., possess early migrating and spawning characteristics). Introduction of the IHN virus to other species is a critical concern with the re-establishment of sockeye salmon in the Yakima Basin. Other potentially adverse interactions are not expected to be caused by sockeye supplementation.

7.6.2 Critical Uncertainties

Further experimental design planning has been delayed pending development of a supplementation objective. However, specific questions being addressed in the Cle Elum feasibility study, for all population response areas include:

1. Will migration timing characteristics of available sockeye salmon stocks be suitable to survive the altered state of the Yakima River system?
2. Will natural reproduction occur?
3. What will be the rate of egg-to-smolt survival?
4. Is the productivity of the lake sufficient to sustain a large juvenile population?
5. Can smolts successfully migrate out of the Yakima River (i.e., passage mortality).
6. What will be the rate of smolt-to-adult survival?
7. What is the carrying capacity of the Cle Elum Lake system (for sockeye and the existing fish community)?

Sockeye re-establishment depends on the success of this feasibility project. The greatest uncertainty is whether smolting sockeye can leave the lake and survive passage downstream to the ocean. The entire project depends on sufficient smolt-to-adult survival of supplemented fish. Egg-to-smolt survival is also a critical uncertainty since hatchery rearing of Lake Wenatchee sockeye (at the National Marine Fisheries Service Laboratory in Seattle) is a new technique.

7.6.3 Experimental Design

Further experimental design planning has been delayed pending development of a supplementation objective.

7.7 KLICKITAT BASIN SUMMER STEELHEAD

7.7.1 Suoolementation Objective

The supplementation objective for Klickitat River summer steelhead is to increase total adult production potential (adult run size to the mouth of the Columbia River at MSY) from an estimated 6,000 to about 12,000 by the tenth year of the program (YIN et al. 1990). The preliminary assessment of the numbers of smolts required to meet this goal is 260,000.

Remaining uncertainties about supplementation opportunities in the basin will be clarified once a better understanding is attained of the current and future passage conditions at Castile Falls. The current production objectives assume no production above Castile Falls. More detailed information about potential release sites both above and below Castile Falls is also needed. This information along with answers to adult and juvenile monitoring feasibility questions are needed to refine the experimental program.

A set of further refined production goals and a more detailed experimental plan for the Klickitat are expected to be completed in time for final design to proceed by April 1992. The schedule is not expected to alter the phased completion of a fully integrated YKPP. The Klickitat components of the project are intended to follow the Yakima components, which are currently at a more advanced planning stage.

The harvest management plan (YIN et al. 1990) projects a 10 to 15% pre-terminal (primarily in the mainstem Columbia) harvest rate, leaving significant additional terminal harvest opportunities for both treaty and non-treaty fishers. The harvest management plan (YIN et al. 1990) reflects a commitment by the managers to the supplementation experiments and to meeting hatchery production goals. The hatchery broodstock goal of 350 adults will be met at natural escapements of 3,500 adults from runs of about 4,100 fish.

7.7.1.1 Assumptions

Primary assumptions which may affect achievement of the supplementation goal include:

1. Post-release survival of hatchery releases will be about 2.9% (smolt-to-adult), or about 50% of expected smolt-to-adult survival rates of naturally produced smolts.
2. Adult and juvenile monitoring capabilities can be established for the Klickitat river system to enable experimental evaluation.
3. Acclimation sites can be identified and established in the system. If not, other means of achieving adequate post-release survival and affecting an optimal natural spawning distribution of hatchery adult returns can be successfully accomplished.
4. Any unique natural sub-stocks (i.e., different from existing hatchery transplants) in the system can be maintained in concert with a large hatchery program.
5. Long-term stock productivity can be maintained under situations where returning hatchery adults annually may represent a large percentage of the total adult return.
6. Large proportions of hatchery releases (to total juveniles) will not limit production potential of natural stocks through intra-specific or inter-specific interactions (e.g., competition or predation).

7.7.2 Critical Uncertainties

7.7.2.1 Post-Release Survival

The expected hatchery smolt-to-adult survival rate is similar to estimated recent performance at WDW hatchery plants. Current hatchery performance could be impacted by significant differences between the hatchery rearing and riverine release environments noted for spring chinook below and exacerbated by direct trucking and release. These factors suggest that rearing and release strategies represent a critical uncertainty affecting post-release survival.

Measurement capabilities for post-release survival represent a serious experimental constraint at present since no monitoring stations currently exist. While developing monitoring procedures is a generic need for the entire YKPP, the Klickitat system requires particular attention because of its current status.

The availability of acclimation sites is a also a question due to the numbers of potential sites required and the physical characteristics of the system (steep gradient, etc.). The ability to test effects of acclimation on post-release survival will be partly determined by resolution of this question.

7.7.2.1.1 Pre-Facilitv Needs. Several pre-facility needs exist that must be addressed in order to proceed meaningfully with development of an experimental design plan for the Klickitat Basin. They are highlighted below. Because many of these needs affect more than one response variable, they have not been assigned to specific sub-sections above.

'1. Acclimation options need to be assessed. Current evaluations of both on-site coho and spring chinook acclimation at Klickitat Hatchery will have a significant bearing on approaches to achieve the needs of optimal post-release survival and affecting adequate natural spawning distribution inherent in the supplementation objective.

2. The genetic/biological characteristics of current natural and hatchery populations of steelhead (including winter-run) need to be comoared in order to assess the planning Premise of the program.

3, Monitoring options need to be identified and tested that will meet the experimental requirements of the program. Smolt and adult enumeration and sampling capabilities near the mouth are the highest priority need for enabling meaningful experimental design planning. Sampling strategies that insure the integrity of the experimental program for in-river fisheries also need to be developed.

4. Current and future passage conditions at and carrving capacity above Castile Falls need to be determined.

5. The production and evaluation strategies for Klickitat summer steelhead need to be re-assessed to evaluate consistency with stated objectives. Resolution of the previous pre-facility planning needs will be an important component of this assessment.

7.7.2.2 Reproductive Success

The availability of acclimation sites also may'liinit'the experimental' capability to test the effect of release strategies on assumptions'relating to reproductive success. Some method of rearing/release will be required to insure adequate spawning distribution. The large percentage of hatchery fish expected to return, coupled with high harvest-rates,. means that the sub-basin's ability to achieve optimum seeding from natural spawners will be heavily reliant upon hatchery returns. If unique sub-stocks of- summer steelhead do exist in the Klickitat Basin proposed supplementation strategies would represent a high risk of impact reproductive success and-long-term fitness due to the large hatchery program.

Monitoring uncertainties also have obvious implications with respect to measuring reproductive success (and long-term fitness below):

7.7.2.2.1 Pre-Facilitv Needs

7.7.2.3 Lonq-Term Fitness

Maintenance of fitness, or maximizing long-term production potential, becomes a large uncertainty considering the relative magnitude of the planned hatchery release.

7.7.2.3.1 Pre-Facilitv Needs

7.7.2.4 Species Interactions

The large hatchery production program increases the likelihood of negative interactions with natural juveniles. This could significantly limit reproductive success, both intra-species and inter-species. The potential for interaction between winter and supplemented summer steelhead is a potential problem.

7.7.3 Exoerimental Desian

No pre-facility or post-facilitv exoerimental hypotheses or needs have been identified because of the major uncertainties that must be resolved in order to progress with meaningful exp'erimental design development.

7.8 KLICKITAT BASIN SPRING CHINOOK

7.8.1 Supplementation Objective

The supplementation goal for Klickitat River spring chinook is to increase adult production potential (adult run size to the mouth of the Columbia River at MSY) from an estimated 3,000 to about 20,000 by year 10 of the program (YIN et al. 1990). The preliminary assessment of the numbers of smolts required to meet this goal is 3.0 million. Out of the 3.0 million smolts needed the existing WDF Klickitat facility will produce about 600,000 with the remainder planned for the new facility.

Remaining uncertainties about the supplementation opportunities in the basin will be clarified once a better understanding is attained of the current and future passage conditions at Castile Falls. The production objectives above assume no production. above Castile Falls. More detailed information about potential release sites both above and below Castile Falls is also needed. This information, along with answers to adult and juvenile monitoring feasibility questions, are needed to refine the experimental program.

A set of further refined production goals and a more detailed experimental plan for the Klickitat River are expected to be completed in time for final design to proceed by April 1992. This schedule is not expected to alter the phased completion of a fully integrated YKPP. The Klickitat River components of the project are intended to follow the Yakima River components, which are currently at a more advanced planning stage.

The harvest management plan (YIN et al. 1990) projects a preterminal harvest rate (in ocean and mainstem fisheries) of about 20%, leaving significant additional terminal harvest opportunities for both treaty and non-treaty fisheries. The harvest management plan (YIN et al. (1990) reflects a commitment by the managers to the supplementation experiments and to meeting hatchery production goals. The combined hatchery broodstock goal of 2,900 adults will be met at run sizes of about 4,150 fish.

7.8.1.1 Assumptions

Primary assumptions that may affect achievement of the supplementation goal include:

1. Post-release survival of hatchery releases will be 0.6% (smolt-to-adult), or about 15% of expected smolt-to-adult survival rates of naturally produced smolts.
2. Adult and juvenile monitoring capabilities can be established for the Klickitat River system to enable experimental evaluation.
3. Acclimation sites (up to 40) can be identified and established in the system. If not, other means of achieving adequate post-release survival and affecting even natural spawning distribution of hatchery adult returns can be successfully accomplished.
4. Unique natural sub-stocks (i.e., different than existing hatchery population) do not exist in the system.
5. Long-term stock productivity can be maintained under situations where returning hatchery adults annually may represent up to 90% of the total adult return.
6. Large proportions of hatchery releases (to total juveniles) will not limit production potential of natural stocks through intra-specific or inter-specific interactions (e.g., competition or predation).

7.8.2 Critical Uncertainties

7.8.2.1 Post-Release Survival

The expected hatchery smolt-to-adult survival rate is similar to estimated recent performance at the WDF Klickitat Hatchery but less than what would seem accomplishable from a watershed relatively low in the Columbia Basin. Current hatchery performance is believed to be impacted by significant differences between the hatchery rearing and riverine release environments, suggesting that hatchery release strategies are a critical uncertainty affecting post-release survival.

The measurement capabilities for post-release survival represent an experimental constraint at present since no monitoring stations currently exist. While developing monitoring procedures is a generic need for the entire YKPP, the Klickitat system requires particular attention because of its current status.

The availability of acclimation sites is an operational question due to the numbers of potential sites required and the physical characteristics of the system (steep gradient, etc.).

7.8.2.1.1 Pre-Facility Needs. Several pre-facility needs exist that must be addressed in order to proceed meaningfully with development of an experimental design plan for the Klickitat Basin. These needs are highlighted below. Because many of these needs affect more than one response variable, they have not been assigned to specific subsections above.

1. Acclimation options need to be assessed. Current evaluations of both on-site coho and spring chinook acclimation at Klickitat Hatchery will have a significant bearing on approaches to achieve the needs of optimal post-release survival and affecting adequate natural spawning distribution inherent in the supplementation objective.

2. The genetic/biological characteristics of current natural and hatchery populations of spring chinook need to be compared in order to test the planning premise of the oroaram.

3. Monitorins options that will meet the experimental reauirements of the program need to be identified and tested. Smolt and adult enumeration and sampling capabilities near the mouth are the highest priority need for enabling meaningful experimental design planning. Sampling strategies that insure the integrity of the experimental program for in-river fisheries also need to be developed.

4. Current and future passage conditions at and carrving caoacitv above Castile Falls need to be determined.

5. The Production and evaluation strategies for Klickitat spring chinook need to be reassessed to evaluate consistency with stated objectives. Resolution of the previous pre-facility planning needs will be an important component of this assessment.

7.8.2.2 Reproductive Success

The availability of acclimation sites also may affect experimental opportunities to evaluate impact of hatchery strategies on reproductive success. Some method of rearing/release will be required to insure adequate spawning 'distribution. The large percentage of hatchery fish expected to return, coupled with high harvest rates, means that the sub-basin's ability to achieve optimum seeding from natural spawners will be heavily reliant upon hatchery returns.

The assumption of no unique (different from hatchery fish) genetic sub-stocks in the basin may be reasonable given current hatchery and natural production characteristics. If unique sub-stocks do exist in the Klickitat Basin, proposed supplementation strategies would represent a high risk of impacting.reproductive success and long-term fitness. The low-risk assessment of a large hatchery program to existing and continued stock productivity is premised on the, hatchery stock assumption.

Monitoring uncertainties also 'have obvious implications with respect to measuring reproductive success (and long-term fitness below).

An uncertainty also exists with respect to operation of current hatchery programs in the Klickitat Basin.

7.8.2.3 <u>Long-Term Fitness</u>

Maintenance'of fitness, or maximizing long-term production potential, becomes a large 'uncertainty considering the relative magnitude of the planned hatchery release. The current protocol for broodstock collection probably would not fit the natural/hatchery production balance expected with reasonable levels of hatchery post-release survival. Regardless of the production guidelines used, very few, if any, generations of natural smolts would be produced from successive broods of natural spawners.

7.8.2.3.1 <u>Pre-Facility Needs</u>. See above.

7.8.2.4 <u>Species Interaction</u>

The large hatchery production program increases the likelihood of negative interactions with natural juveniles. This could significantly limit reproductive success, both intra-species and inter-species.

7.8.2.4.1 Pre-Facility Needs. See above.

7.8.3 Experimental Design

No pre- or post-facility experimental hypotheses or needs have been identified because of the major uncertainties that must be resolved in order to progress with meaningful experimental design development.

8.0 MONITORING PROGRAM

A monitoring program is being developed to measure responses of salmon and steelhead in the Yakima and Klickitat Basins to supplementation activities. Responses are measured in terms of survival by life stage (post-release survival), reproductive success, long term fitness (genetics monitoring), and interaction effects. The monitoring program should also measure response variables with statistical confidence.

8.1 RESPONSE VARIABLES

The supplementation goals for the project are stated in terms of adult production potential. Evaluation of the success of the project depends on measuring adult returns of both naturally-produced and hatchery (supplementation) fish as well as long-term fitness and effects of supplemented populations on other species. Intermediate response variables (i.e., smolt survival to Prosser Dam or other smolt evaluation facilities) must be monitored to indicate refinement of the overall strategies for improving production of anadromous fish in both basins. The experimental objectives also require measurement of intermediate response variables to permit statistical analysis of differences among treatment groups. The monitoring program must also include methods to distinguish among marked groups of fish throughout their life cycle. All state-of-the-art methods of marking groups of fish will be evaluated and the "best complement" of methods will be selected for each application. This is an important pre-facility task.

The response variables that must be measured include: 1) survival of fish from the point of release through out-migration, 2) contribution to major fisheries, 3) adult returns to the sub-basin, and 4) spawning. Additional measures of reproductive success and long-term fitness of the supplemented sub-stocks are also needed and will require specialized techniques. Development of appropriate methods for monitoring these characteristics is a primary goal of the pre-facility experimental program.

Response variables for studies of genetic effects of supplementation, intra-specific and inter-specific interactions, and stock assessment must be identified and coordinated within the monitoring program. Sampling rates, schedules, and procedures (i.e., what, when, how to measure) will be refined as pre-facility research questions are answered.

8.2 SAMPLING RATES

The monitoring design is to examine a minimum 35 fish per replicate for each treatment and control group. This provides statistically significant data at the level of detection and power selected for the control-treatment experiments (see Section 5.3). Because there is a tradeoff between sampling rates and the size of marked groups, the marked groups can be smaller at higher sampling rates.

Table 8.1 provides preliminary estimates of the number of marked adults to be sampled, assuming three replicates per treatment and control group, and can be used for purposes of facility planning (see Chapter 9.0). About half as many adults will be sampled at Roza Dam and at the Naches site. A constant monitoring rate is assumed over the duration of the migration period.

8.3 MONITORING LOCATIONS

8.3.1 Yakima River

Adult and juvenile monitoring capabilities are required and various locations in the Yakima sub-basin. While specific sites and monitoring needs will be defined as a result of pre-facility research and experimental design planning, project needs have been identified below.

Mainstem adult monitoring is required at the following locations: 1) Prosser Dam, 2) Roza Dam, 3) Cowiche Dam, and 4) Horn Rapids Dam (potentially for fall chinook).

These sites will be important for measuring smolt-to-adult survival rates for various treatments.

Mainstem juvenile monitoring is required at: 1) Chandler Dam, 2) Rosa Dam, 3) the Naches River (to be determined), and 4) the lower Yakima River. These sites will be important for measuring juvenile (e.g., survival to smolt) response variables.

TABLE 8.1. Anticipated Number of Adult Returns to be Sampled at Lower River Monitoring Locations. Sampling methods depend on the tag used.

Stock	Lower Yakima # Proposed Treatments (Replicates)[(a)]	Lower Yakima # Samples	Lower Klickitat # Proposed Treatments (Replicates)	Lower Klickitat # Samples
Spring Chinook	7 (21)	735	To be Determined	
Summer Chinook	1 (3)	105	NA	---
Fall Chinook	6 (18)	630	NA	---
Coho	3 (9)	315	NA	---
Summer Steelhead	3 (9)(b)	315	To be Determined	

(a) See Chapter 9.
(b) An additional treatment group (3 replicates) may be used in the upper Yakima River to study steelhead/trout interactions.

In addition to these mainstem sites, juvenile and adult monitoring capabilities (i.e., smolt and adult enumeration/sampling) likely will be needed in control and supplemented tributaries. These sites include Satus, Toppenish, and Cowichee Creeks for steelhead and American River for spring chinook. Measurement of response variables for related to reproductive success, long-term fitness and species interaction would be an essential objective of these monitoring sites. Similar measurement needs may exist at numerous adult spawning and juvenile incubation/rearing sites throughout the sub-basin.

8.3.2 Klickitat River

Adult and juvenile monitoring needs have not yet been evaluated as carefully in the Klickitat sub-basin as the Yakima sub-basin. Nevertheless, upstream/downstream monitoring definitely will be required in the lower Klickitat River, with Lyle Falls being the preferred site. Monitoring at Castile Falls may be required depending on passage status at and potential experimental above this site.

8.3.3 Mainstem Columbia River

Mark recovery data (adults and juveniles) from mainstem facilities at McNary Dam is essential. Additional sampling opportunities to obtain the needed information from other mainstem locations (e.g., Bonneville Dam) should be determined. Available information indicates that adequate juvenile monitoring capabilities do not currently exist at Bonneville. These facilities would assist to meeting the YKPP monitoring objectives.

9.0 FACILITY REDUIREMENTS

The facility requirements from an experimental perspective focus on two main areas of interest. The first set of requirements lies in designing the rearing and acclimation/release facilities to minimize the variables complicating statistical analysis of experimental results developed for the project. The second set of experimental requirements deals with development of reliable monitoring/data collection facilities for evaluation of experimental release groups.

9.1 YAKIMA BASIN

9.1.1 Incubation and Rearinq Facilities

Facilities and procedures for juvenile rearing in the main hatchery will be developed to allow each of the replicate treatment and control groups to be treated as similarly as possible. This will include having the same water source, feeding rates, rearing densities, etc. Many of these requirements have been factored into the facility designs by the engineers. The main facility layout for the Yakima Basin will include three main hatchery sites to be located at Cle Elum on the upper Yakima River, and at Nelson Springs and Oak Flats on the Naches River. The following section describes the various species/stocks that are slated for supplementation and where the adult holding, egg take and incubation, and rearing will occur.

Sprinq Chinook

The Cle Elum site will be used to hold spring chinook adults taken from Roza Dam as brood stock for the upper Yakima genetic sub-stock (this may need to be revised as results from genetic studies emerge). The adult spring chinook will be spawned at Cle Elum, eggs will be incubated, and juveniles will be reared to produce 1,150,000 fish for release at 15 fish per pound. The fish will be released through 15 acclimation facilities as discussed in following section.

The site at Cle Elum will also be used for final incubation and for rearing the spring chinook for the Naches River. Naches spring chinook adults will be taken at Cowiche Diversion Dam and spawned at Oak Flats (brood stock collection sites may change based on genetic study results). The eggs will be incubated to the eyed stage at Oak Flats and then transferred to the Cle Elum main facility for final incubation and rearing. These spring chinook will then be transferred back to the Oak Flats main facility for final rearing and the resultant pre-smolts transferred to the six acclimation sites on the Naches River system for release.

Summer Steelhead

Summer steelhead adults will be collected at Cowiche Diversion Dam (subject to genetic study results), and spawned at the Nelson Springs main facility. The egg incubation and early rearing will occur at Nelson Springs. The final rearing will be split between the Nelson Springs and Oak Flats sites with 50% of the juveniles at each main facility.

The resultant 400,000 pre-smolts will then be transported to six acclimation facilities on the Naches system (200,000 fish) and three acclimation facilities on the Toppenish system (100,000 fish). Sites for three additional acclimation facilities have been identified for possible interaction research experiments on the upper Yakima River (100,000 fish).

Fall Chinook

Fall chinook adults will all be collected at the Prosser Dam ladder/trap facilities and held at a pond near Prosser Dam. The eggs will be incubated at Nelson Springs facility, and early rearing will also occur there. The final rearing and acclimation will be split between the two satellite sites at Prosser and Wapato Dams. A total of 2,400,000 smolts will be volitionally released at Wapato Dam and 1,200,000 fish at Prosser Dam.

Summer Chinook

Adult summer chinook will be collected at Cowiche collection facility, held, and spawned at Oak Flats, with egg incubation, rearing, acclimation, and release of 200,000 fish at Oak Flats.

Coho

Coho adults will be collected at the Prosser trap (possibly Cowiche Dam in the future), held and spawned at the Prosser satellite facility, incubated and reared at Oak Flats, and acclimated and released at Oak Flats (300,000 fish) and the Wapato satellite facility (1,700,000 fish).

9.1.2 Acclimation Facilities

The acclimation facilities for spring chinook and steelhead trout are also being designed to standardize the treatment of final rearing of the release groups. The acclimation facilities have been standardized as 9,000 cubic foot ponds with a density factor of 1.1 (1/2 that of raceways), with a flow of 525 gpm/pond (1.2 cfs/pond). Each pond will be used to finish rearing and acclimate 75,000 spring chinook smolts at 15 fish per pound or 25,000 to 33,0000 steelhead smolts at 7 fish per pound. The ponds will be earthen structures with cobble bottom to simulate natural conditions as much as possible. The ponds will need to be totally drained and may be gravity fed or require pumping in some situations.

On the upper Yakima River there will be three clusters with three acclimation sites per cluster, each with the potential for two ponds per site. In the initial production stages of the project, there will only be one pond constructed per site. This pond will be for acclimation and release of spring chinook. The option of constructing a second pond at each site will be used for the acclimation and release of steelhead trout if that is decided to be the study design after collection of the baseline data on resident trout/steelhead. The current potential locations of these clusters are at the Ellensburg Town Dam, near the main hatchery facility at Cle Elum, and just downstream of the Easton Dam site. There is also the potential for a cluster of sites at the Roza Diversion Dam, but this is a lower priority site due to the limited current natural production in this area.

Acclimation site clusters will be selected from the following upper Yakima River tributaries: the Teanaway River (one mainstem site, two sites in the North Fork, and one potential site in the Middle Fork, dependent on the building of a storage reservoir on this fork); on the Cle Elum River; and in the section of the upper Yakima River between Easton and Keechelus Dams (this section was designated as a tributary rather than as a mainstem section).

Naches-system acclimation sites will be selected from the Bumping River, the Little Naches River, the Rattlesnake Creek, and the Cowiche Creek. These sites will be the same as those described for the upper Yakima River with ponds at each site for 75,000 spring chinook and 33,000 steelhead smolts.

A maximum of three sites will also be developed on the Toppenish Creek system for steelhead releases.

Table 9.1 lists all of the sites that are currently being considered for acclimation and release ponds in the various reaches of the Yakima Basin. This table also includes the species, numbers of fish released, size at release, and date of release.

9.1.3 Monitoring/Data Collection Facilities

The monitoring/data collection facilities need to be developed or upgraded to allow for measurement of the response variables with a predetermined degree of statistical confidence. The response variables to be monitored include survival by lifestage, long-term fitness (genetic monitoring), and interactions among and between species.

Adult Sampling

Adult sampling will need to be done at Roza Dam (an off-ladder collection facility is in the engineering pre-design phase), in the lower Naches (engineers are determining feasibility and costs of developing adult sampling facilities at Oak Flats, Wapato, and the Naches-Cowiche Diversion Dam), and face at the Prosser Diversion Dam (current trap is operable). Sampling capability is needed at each of the Naches sites. Additional counting capability is needed and being developed at Easton Diversion Dam (video camera and window) and at a site in the lower mainstem Yakima. The inclusion of PIT tag detectors at each of the sites is being considered.

Juvenile Samoling

Juvenile sampling capabilities need to be 1) expanded at Roza Dam (plans are being developed to build off-spillway holding capabilities to reduce labor costs at this site), 2) built at a site in the lower Naches system (possibly at the same site of the adult sampling facility), and 3) developed in the

TABLE 9.1. Release/Acclimation Locations

Watershed	Site	Species	Receive Date	Release Date	Fish/ lb	Number
Lower Yakima	Prosser	F. Chinook	3/19	5/28	65	1,200,000
	Wapato	F. Chinook	3/19	5/28	65	1,200,000
	Wapato	Coho	3/1	5/1	15	1,400,000
	Toppenish Creek	Steelhead	3/1	5/1	7	100,000
	Unknown, e.g., Wapato, also/or					
	Nelson Springs	F. Chinook	5/5	5/28	65	1,200,000
Naches	Oak Flat Hatchery RM 19.5 (Main r.)	Sum. Chinook	On-Station	4/25	15	200,000
	Bumoinq					
	1. Sunrise Creek	Sp. Chinook	3/1	4/25	15	75,000
		Steelhead	3/1	5/1	7	33,000
	2. Dam Site	Sp. Chinook	3/1	4/25	15	75,000
		Steelhead	3/1	5/1	7	33,000
	3. Alternate at Goat Creek	Sp. Chinook Steelhead				
	Cowiche	6th Alternate				
		Steelhead	3/10	5/1	7	66,000
		Coho	3/10	5/1	15	150,000
	Little Naches					
	1. Fawn Creek	Sp. Chinook	3/15	4/25	15	75,000
		Steelhead	3/15	5/1	7	33,000
	2. Beaver Creek	Sp. Chinook	3/1	4/25	15	75,000
		Steelhead	3/1	4/1	7	33,000
	(Alternate)					
	a. SF Naches	Sp. Chinook	3/15	4/25	15	

TABLE 9.1. (contd)

Watershed	Site	Species	Receive Date	Release Date	Fish/ lb	Number
	Matthews Meadow	Steelhead	3/15	5/I	7	
		Sp. Chinook	3/15	Alternate		
		Steelhead	3/I	Alternate		
	b. Country Creek FS 1913		3/I			
	c. Quartz Creek					
	Rattlesnake					
	1. R. Spr.	Sp. Chinook	3/15	5/I	15	75,000
	2. N. Fork	Steelhead	3/15	5/I	7	33,000
	Little Rattlesnake					
	1. 3 Mile Site	Steelhead	3/I	5/I	7	33,000
	2. 7 Mile Site	Steelhead	3/15	5/I	7	33,000
	Main Stream (see Oak Flat)	Alternates Sp. Chinook Steelhead Coho				
	1. Swamp Creek					
	2. Gold Creek					
	3. Irrigation Canal at RM 30					
	Nile Creek	5th Alternate				
		Coho	3/10	5/I	15	150,000
Upper Yakima Main stem	Town					
	1. Ditch	Sp. Chinook	2/25	4/20	15	75,000
	2. Dry Creek	Sp. Chinook	2/24	4/20	15	75,000
	3. KID Canal	Sp. Chinook	2/24	4/20	15	75,000
	4. Thorp B	Sp. Chinook	2/24	4/20	15	75,000
	(Alternate)					

TABLE 9.1. (contd)

Watershed	Site	Species	Receive Date	Release Date	Fish/ lb	Number
	1. Cle Elum Hatchery	Sp. Chinook	2/24	4/20	15	75,000
	2. 1 Mile Below	Sp. Chinook	2/24	4/20	15	75,000
	3. 2 Miles Below	Sp. Chinook	2/24	4/20	15	75,000
	1. Easton Screen	Sp. Chinook	3/5	4/20	15	75,000
	2. Easton Pond	Sp. Chinook	3/5	4/20	15	75,000
	3. 2 miles below	Sp. Chinook	3/5	4/20	15	75,000
Teanaway	4.0 Mile Bridge	Sp. Chinook	3/1	4/20	15	75,000
	Indian Creek, or	Sp. Chinook	3/5	4/20	15	75,000
	Middle Creek, or	Sp. Chinook	3/5	4/20	15	75,000
	Giustett-Bussoli Canal	Sp. Chinook	3/5	4/20	15	75,000
Above Easton	Telephone Creek	Sp. Chinook	3/5	4/20	15	75,000
	Hudson Creek	Sp. Chinook	3/5	4/20	15	75,000
	Dam Site	Sp. Chinook	3/5	4/20	15	75,000
Cle Elum River		(Alternate)				

lower mainstem Yakima River (WDF is developing mobile sampling gear to be tested here). The juvenile evaluation site at Chandler is the only currently full-time operating facility in the Yakima basin. Bhandler, and other planned sites, need to have capture efficiencies determined before outmigration can be estimated at each site. The protocol as described by Burnham et al. (1987) would be utilized for statistical evaluation in the basin. This approach would require a minimum of three sites where fish could be monitored. The use of PIT tags would allow development of sites that would minimize handling of fish, yet maximize information collected from fish passing through trap facilities with tag detectors.

9.2 KLICKITAT RIVER

Planning for the Klickitat Facility is lagging behind the Yakima because of the lack of adult and juvenile sampling facilities. There is also a lack of baseline information on which to base sound biological decisions on where and how best to design experiments in the basin. Thus, planning of strategies for release of fish in this basin will probably fall several years behind similar planning efforts in the Yakima Basin.

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YAKIMA/KLICKITAT PRODUCTION PROJECT
GENETIC RISK ASSESSMENT

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March 21, 1990

1. Introduction

Concern for the conservatlon of fish genetic resources currently plays a large **and** growing role In the management of fish populations, particularly management of salmon and steelhead stocks of the Pacific Northwest. This concern was recently underscored at a workshop on genetic conservation and production principles held in December 1989 at the Northwest Power Planning Councll (hereafter referred to as the Council). The consensus of the workshop participants (approximately twenty genetlclsts from all over the country), was that a sustainable Increase in the productivity of Columbla basin salmonlds cannot be achieved without conservation of the genetlc resources in these stocks. Genetic conservatlon and the Council's goal of doubling salmon and steelhead production in the Columbia basin are thus lnextrlcably intertwined.

The Council's support for genetic conservation efforts is clearly enunciated in As 1987 Columbia River Basin Fish and Wildlife Proaram (Section 204, paragraph b), in which the conservatlon of genetic resources was established as a system goal. An essential aspect of the Council's commitment to genetic conservation ls a stlpulatlon that a genetic risk assessment be done In plannlng for any production project under the Council's purvlew (Columbia Rlver Basin Fish and Wildlife Proaram, Sectlon 204, paragraph b). This document is presented in fulfillment of the requlrement that genetic risks be assessed for the Yakima/Kllckitat Production Project (YKPP).

This YKPP genetic risk assessment is necessarily preliminary, for three reasons. First, a standard Council format for genetic risk assessment has not yet been established. Genetlc risk assessment tools, including a software expert system, are being developed by the Council's Monltoring and Evaluation Group (MEG), but are not yet operational. This document does follow many baslc concepts for genetlc risk assessment now being developed by MEG, but it will need to be revised as rlsk assessment tools and a standard format become available from MEG.

Second, too little information is available on the fish stocks potentially at rlsk In the YKPP to permlt a detailed risk assessment. This is especially true of the Klickitat subbasin, where relatively little research into stock structure has been done and population monitoring facilities are virtually nonexistent (see Klickitat Subbasin Plan), but is also true of the Yakima subbasin, where Yakima Indian Nation biologists have collected a considerable amount of information (especially on spring chinook [e.g., Fast et al. 1988]), and numerous fish monitoring facilities exist (e.g., traps at Roza, Wapatox, and Prosser). The assertion that not enough data are available to permit a detailed risk assessment is not a criticism of research done to date in the Yakima and Kilckitat subbasins, but rather a reflection of the amount and kinds of data that are necessary for this task. A fundamental informational need for genetic risk assessment, for example, Is knowledge of the substock structure of target species and runs, and this information is not yet available for the YKPP. The case of spring chinook illustrates this problem well. There are thought to be at least two substocks In the Yakima subbasin, but there could be several more. In the Klickitat subbasin, it is not even known If a wild spring chinook stock still exists. More detalied data on substock structure has been identified as a critical prefaciiity informational need in the YKPP Experimental Design Plan. Extensive sampling of chinook and steelhead in both subbasins for substock identification research began in 1989. As this new information becomes available, the YKPP genetic risk assessment will obviously have to be revised.

The third and final reason this genetic risk assessment must be considered preliminary is the YKPP's emphasis on adaptive management. As new information comes to light, either from direct experimentation or from population sampling, YKPP operations will adapt to the new information, shifting operational parameters such as hatchery production levels, stocking rates, and broodstock collection procedures. This can have a major impact on the genetic risks entailed in the production effort. As genetic risks shift as a result of changes in YKPP production approaches, the genetic risk assessment will have to be revised.

it should be kept in mind that this initial YKPP genetic risk assessment is preiimlnary, but not tentative. Despite the lack of information on which to base a detalied assessment of genetic risk, and the certainty of future revisions, it Is possible at this point in planning to make a careful, well researched assessment of genetic risks posed to saimonid stocks by the YKPP.

2. Categories of Genetic Risk

Current genetic risk assessment planning by MEG has identified three types of genetic risk: 1) extinction, 2) loss of within population variability, and 3) loss of population identity (between population variability). Extinction represents the most extreme type of risk. Once a population is extirpated, all its genetic variability is irretrievably lost. Any genetic uniqueness represented by that population Is gone. Current evolutionary thought suggests that ail fish populations are unique at some level, so every population extirpation probably represents a reduction of the overall genetic variability occurring in that species. Extinction can be caused by any activity that reduces a population below a minimum viable level. Typical potential causes, acting alone or in combination, for saimonid populations in the Northwest are overharvest, passage difficulties, and habitat degradation, Extinction is less of a risk in hatchery operations, but scenarios can be envisioned in which hatcheries could play a role in extinction. if hatchery egg takes cause wild spawners to fall below critical numbers, and the hatchery fails, extinction would result. A disease outbreak In the hatchery necessitating destruction of broodstock could cause the population overall to fail below a minimum viable size. Another possibility is ecological displacement by large numbers of hatchery fish (Lichatowlch and McIntyre 1987) causing the wild population to fall below the minimum viable number.

The second type of risk, loss of within-population variability, is commonly associated with hatchery production. There are actually two major categories of Type 2. Type 2a risk is loss of variability due to genetic drift, a problem common to all finite populations. If the population is large enough, this loss through drift is compensated for by the creation of new variability by mutation, but captive populations are generally too small for this compensation to occur. The result is a gradual loss of variability and concurrent increase in homozygosity. Since genetic variability is the raw material upon which selection acts, this loss in variability becomes a loss in responsiveness to natural selection. Population fitness will suffer. Loss of variability is related to effective population size rather than census population size. In an Meal population the numbers are the same, but differential contributions of the two sexes to the progeny, varying family sizes, and annual variation in number of spawners can make the effective size of a population much smaller than the census number. This is probably the most common type of genetic risk imposed by hatcheries. Occurrence of loss of genetic variabillty to genetic drift has been documented on several occasions (Aliendorf and Phelps 1980, Ryman and Stahl 1980), and Is commonly addressed in hatchery manuals in the form of recommendations on spawner numbers and sex ratios (e.g., Hershberger and lwamoto 1983, Kapuscinskl and Jacobsen 1987).

Type 2b risk is loss of variability due to nonrandom sampling of a population in collecting broodstock. Significant portions of the stock's genetic variability may thus be omitted from the cultured stock. This phenomenon is often called founder effect. It can easily occur in hatchery operations. Typical situations include taking eggs from the earliest spawners until a quota is met rather than taking eggs from throughout the entire spawning period, and using jacks as spawners In proportions much lower than their occurrence in the spawning popuiatlon. Leary et al. (1989) recently demonstrated that the genetic profile (evaluated by starch-gel eiectrophoresis) of a rainbow trout broodstock varied significantly over the spawning season; especially interesting was the fact that spawners in the middle of the season were more varlable than either early or late spawners.

The third type of genetic risk is loss of between-population variability, which can also be described as loss of population identity. If two populations are mixed, there may be no loss of genetic material overall, but the genetic distinctness of the two populations, based on the genes they separately contained at particular frequencies, will be lost. The mixing will cause a recombining of genes that had formerly occurred in high-fitness combinations called coadapted complexes, Particular desirable genotypes distinguishing a population, such as run timing or body size, may become absent or less frequent. The new combinations of genes may result in lower fitness in the mixed population, a phenomenon called matadaptation. Mixing can occur on wholesale levels, such as the deliberate mixing of stocks intercepted on a mainstem location for a hatchery broodstock (e.g., Bonneville Upriver Bright fail chinook), or on a much smaller scale through straying. Loss of population identity is a common risk in hatchery operations. Stock mixing is often deilberateiy done to meet egg take requirements, and straylng can be exacerbated by particular release and transportation strategies. Another possibility is the genetic swamping of a wild population with wild spawning hatchery fish of another stock.

A fourth type of genetic risk, domestication selection, needs to be considered in assessing the impact of hatchery operations on salmon and steelhead. Hatcheries, despite attempts to avoid causing genetic change in the cultured stock, may impose new selection regimes on the fish in the course of standard flsh culture techniques, causing increased fitness in the hatchery environment, but decreased fitness in the wild. Two groups of researchers working with steelhead (Reisenbichier and McIntyre, 1977; and Chilcote et al., 1986) have concluded that domestication selection does occur. Considerable controversy surrounds this potential genetic risk. There is no clear consensus among geneticists regarding the importance of domestication selection, but the possibility of domestication selection being an unavoidable consequence of hatchery operations is a popular argument against hatchery programs voiced by lay critics (e.g., Bakke 1989).

3. Minimizing Genetic Risk in Anaciromous Salmonid Production Programs

Genetic risk can be minimized considerably by careful management of fisheries and hatchery operations. Type 1 risk, extinction, often can be minimized (after ail possible has been done to improve fish passage and habitat) by minimizing exposure of a stock to harvest. This can present problems, since salmonids are often harvested in mixed-stock fisheries, and targeting very strong stocks can harvest weaker stocks at excessive rates. There are two solutions. The first is to target stocks speciflcaiiy by harvesting in terminal areas; the second is to manage the fishery for protection of the weak stocks by monitoring harvest by coded-wire tags or genetic stock identification (GSI). GSI is a very promising approach, currently being used In season to regulate the harvest of upper Columbia and Snake spring chinook stocks in the lower Columbia winter gill-net fishery. Extinction due to excessive egg take for hatchery operations can be prevented by limiting the use of wild brood stock to a specified percentage of the population based on solid demographic information. Extinction due to ecological interactions with hatchery fish is more problematic. More research into interactions between wild and hatchery fish needs to be done to determine how important a risk this is.

Considerable control can be exerted over Type 2a risk, loss of within-population variability due to genetic drift. The key is accurate estimation of effective population size, which requires information on age structure, sex ratio, and number of spawners. In a population not being supplemented, once effective population size has been estimated, escapement must be controlled to keep the effective number sufficiently high to avoid excessive loss of genetic variability. This will probably require management of the harvest. in a hatchery, in addition to considering the demographic factors already listed, attention has to be paid to spawning protocols. Mixing milt from several males for application to a batch of eggs can greatly Inflate variability in famliy size, significantly lowering the effective population size (Gharrett and Shirley 1985, Wiihler 1988). It is possible in a hatchery to actually increase the effective size over what it had been in an unsupplemented wild stock.

Type 2b risk, loss of variability due to founder effect is theoretically simple to minimize. All that is required is random sampling of the stock for broodstock, taking care that enough fish are sampled that variability is not lost. In practice this can be quite difficult, however. Sampling spawners throughout a run to achieve an egg take which meets a production quota can be risky to the hatchery manager. Many early returning fish will have to be passed upstream to reserve holding space for later flsh; if the anticipated later returns do not materialize, the egg take goal will not be met. The alternative Is to hold surplus fish as insurance against this contingency, which is obviously undeslrable in a supplementation plan designed to otherwise minimally interfere with natural spawning. Another potent&l consequence of attempting to sample spawners throughout the run is excess egg take. An excess egg take may seem genetically the right thing to do, but again may seem to be a heavy impact on wild spawners in a supplementation program. Moreover, there may be pressure from the public to use these eggs, either by releasing more smolts than the program was designed to do, or by fry outplantlng, which may not be wise genetically. A possible but as yet unexplored way to solve this problem Is through partial spawning of fish In the hatchery and then releasing them to the wild. Thls may well prove to be feasible wlth some stocks but not others. A partially spawned fall chinook which has been held for a short time In the hatchery may behave normally in the wild, but it is questionable whether a summer steelhead or spring chlnook, after months of being held In the hatchery, would spawn normally In the wild. A very common situation in which the genetically correct procedure conflicts with public pressure is in the use of jacks as spawners. The incidence of jacks in a stock can easily be increased by production of large smolts, which are desirable from a cultural standpoint because of their high survival rates. In some spring chinook hatcheries, the age structure of the population can be significantly shifted downward to the point where up to half the spawners return as jacks, compared to a prefacillty situation of virtually no jacks. Using jacks in the proportion in which they occur may be correct genetically, but the public may consider the increased production of jacks unacceptable. A reflection of this problem is the recommendation in a current Washington Department of Fisheries (WDF) hatchery operations manual (Seidei 1983) that jacks make up no more than 2% of the spawners in a hatchery operation, regardless of their proportion in the returning fish.

Type 3 risk, the loss of population ldentlty, can be minimized by first obtalnlng a detailed knowledge of the substock structure of the fish being Impacted by the production program, and then avoiding mixing substocks. A thorough genetlc survey of the populations subject to risk should have a hlgh prlority In prefaciiity plannlng. Normally thls will be done through electrophoretlc analysis. Once the stock structure Is understood, steps must be taken to malntaln it. Broodstock coilectlon must be done In sufficlently terminal locatlons to avold a mlxed-stock collectlon. Mlxlng of stocks by uslng fish from another stock to make up production shortages, a relatively common hatchery practlce, must be avoided. Finally, straylng must be monitored, both within and outside the subbasin.

Type 4 risk, domestication selection, in theory obviously can be minlmlzed by restrlctlng the stocks exposure to elements of the hatchery environment which Impose selectlon pressures different from the natural environment. Problems arlse Immediately in trying to put this principle Into practice, however. To begln with, we can guess at them, but we have no real understandlng of the selectlve forces operating In elther environment. Certaln dlfferences between the two environments are obvious, such as the dlfferences In feedlng behavior of fbh in an uncrowded stream compared to those In a hatchery raceway, but it Is not known what the genetlc consequences of these Imposed behavioral differences are. Attempting to mlnlmize the selectlve influence of the hatchery can also confllct with production goals. The Influence of the hatchery can easily be reduced by outplanting fry Immediately after swlmup, but the return rates may be too low to make this feasible. Similarly, producing smolts much larger than natural size Improves return rates, but these fish are definitely exposed to a much different environment during rearing than thelr wild counterparts. One possible approach to minlmlzlng hatchery Influence, whlch Is planned for some new hatchery operations In the Columbla basln, Is marklng all hatchery flsh and taklng only wild-produced fish as broodstock. The intent Is to alternate generations of selectlve effects of the hatchery environment wlth generations of selective effects of the wild environment. Thls method has not yet been tested. Given how little we know about Type 4 rlsk, a monitoring and evaluation program almed at assessing its effects is crucial. Such a program Is dlfficult to Implement, however. Subtle differences in performance, particularly reproductive performance, must be detectable and separable Into genetlc and environmental components. The decomposltlon of performance into genetlc and environmental components Is critical. In most cases monitoring and evaluation will require genetic marking of test groups.

4. General Procedures for Minimizing Genetic Risk in the YKPP

The commitment of YKPP planners to minimizing genetic risk is well Illustrated by the fact that the entire project is designed as an experiment, the central hypothesis of which is that "...new artificial production in the Yakima and Klickitat subbasins can be used to increase harvest and to enhance natural production without adversely affecting genetic resources " (YKPP Experimental Design Plan, executive summary). To this end, certain genetic conservation protocols are bulit Into the project. Since these are common to many YKPP production efforts aimed at Increasing productivity of preexisting stocks, it Is worthwhile to describe these before going on to specific situations pertaining to individual species and races.

4.1 Substock Identification

As has been already emphasized, a detalled understanding of stock structure Is an Integral part of planning to maximize genetic conservation opportunitles and minimize Type 1 and Type 3 risk. Substock identification, Including development of Improved substock definition techniques, has thus been Identified as a critical YKPP prefacllity research activity. The intent Is to thoroughly sample for electrophoretic and scale pattern analysis virtually all major spawning aggregations of preexisting stocks slated for supplementation activity: spring chinook in both the Yakima and Klickitat, summer steelhead in both the Yakima and Klickitat, and fall chinook in the Yakima. Klickitat winter steelhead, which are not proposed for supplementation, will also be sampled. Sampling of most spawning aggregations will be repeating annually through one full generation cycle (4-5 years) to understand annual fluctuations in gene frequencies. Hatchery stocks of chinook, steelhead, and rainbow trout that may have contributed or may still be contributing genetically to YKPP stocks will also be sampled for electrophoresis. Potential substocks identified by life history differences will also be sampled.

4.2 Broodstock Management

Broodstock management will be designed to minimize genetic risk of several types. Returning adults, including jacks, will be randomly sampled at appropriate collection sites to minimize Type 2b risk. Effective population size will be maximized in the hatcheries, by a variety of methods, to minimize losses of variability due to genetic drift (Type 2a risk). Broodstocks will ordinarily consist of at least 100 spawners of each sex, the exception being cases in which taking so many could severely depress wild spawning, lowering the effective number of wild spawners and perhaps dropping the total number of wild spawners to dangerously low levels (Type 1 risk). To guard against this occurrence, no more than 10% of an adult steelhead population and 20% of an adult chinook population will be taken for hatchery broodstock. Gamete mixing will follow recommendations of Gharrett and Shirley (1985) and Withler (1988), to further maximize effective population size. To minimize the possibility of stock mixing in the hatcheries, substocks will be individually cultured. To minimize risk of domestication selection (Type 4 risk), all supplementation fish will be marked and marked fish will be excluded from broodstock collections. Finally, development of improved broodstock management techniques, including investigation of the feasibility of partial spawning, has been designated a critical prefacility need.

4.3 Genetic Monitoring and Evaluation

The YKPP goal, as indicated by the central hypothesis, is to increase production of YKPP stocks without degrading the genetic resources represented by the YKPP stocks. Long term monitoring is required to assess the success of both the supplementation and the genetic conservation effort. Methodologies for YKPP genetic monitoring are still being developed, and will be continually improved on. At this point, however, key elements appear certain. YKPP stocks will be periodically (annually at first, possibly less frequent later) reanalyzed electrophoretically to examine genetic change at structural gene loci over time. Observed gene frequency fluctuations can be compared with theoretical values based on effective population size calculations from normal production population monitoring. Fluctuating meristic asymmetry, which has been shown to be a fairly sensitive indicator of changes in homozygosity (Leary et al. 1988) will be done on the same schedule. Fine-scaled fitness comparisons between hatchery and wild fish will be based on measurement of several survival and reproductive traits.

4.4 Genetic Refuges

Two stocks in the Yakima subbasin, American River spring chinook and Satus Creek summer steelhead, will not be supplemented. Both stocks are characterized by high productivity and little or no hatchery ancestry. American River spring chinook, characterized by a distinctive age structure and spawning timing, have also been previously characterized as a distinct substock within the Yakima subbasin (Howell et al. 1985). Previous WDF electrophoretic analysis has also shown significant genetic differences between the spring chinook of the American River and those of the mainstem upper Yakima. Satus Creek and the American River will be managed as genetic refuges for these two stocks. This management may eventually include construction of weirs across the streams to close them to strays.

5. Genetic Risk Assessment for YKPP Target and Nontarget Stocks

This section presents genetic risk assessments for the individual stocks scheduled for production increases under the YKPP (target stocks) and those stocks which are not part of the YKPP, but may be

Impacted genetically by YKPP production stocks (nontarget stocks). The dlscusslon of nontarget stocks, wlth the exception of Kllckltat winter steelhead, Is limited to ralnbow and cutthroat trout, specles which can reasonably be expected to interbreed with YKPP production stocks (steelhead only; natural trout-salmon hybrids do not occur). Genetic risks can be posed to ecologlcally slmilar species whlch do not Interbreed with YKPP production stocks, but these are strictly of a Type 1 risk caused by displacement. There may thus be populations of Dolly Varden, bull trout, and nonnative brook and brown trout at risk that are not included here because of lack of lnformatlon on them. Kokanee, mentioned In the discussion of Yaklma sockeye, may also generally be at risk, but at this point there Is little Information on the status of kokanee populations in the two subbaslns.

All stocks in a hatchery production program are potentially subject to type 2a, 2b, 3, and 4 rlsks. As described above, however, YKPP operations have been designed to minlmize all these, and to monltor whatever change does occur. Operations can be modified or stopped when slgnlflcant damage or the threat of significant damage Is detected. Slnce all YKPP production stocks will be subjected to these “routine” risks and safeguards to minimize them, these can be taken as given, and will not be discussed below. Another risk that can be considered a possibility for any YKPP stock Is Type 1, caused by mlxed fishery situatlons that may arise as a result of the project’s success. Since these are entirely speculative during the prefacility phase, these risks wlll also not be discussed below.

The background and YKPP productlon Information presented below, unless stated otherwise, was taken from the draft Yakima and Kilckitat subbasln plans, the public revlew draft of the Yaklma River Subbasln Salmon and Steelhead Plan, the Council’s YKPP Staff Issue Paper, and the draft YKPP Experimental Design Plan. More detailed discussions of the genetic status of Yakima and Kllckitat sprlng chinook and steelhead are presented in the substock identification plans prepared by WDF for the YKPP.

5.1 Yakima Spring Chinook

Spring chinook runs to the Yakima subbasln are far below historical levels, but currently range from about 1,000 to 10,000 fish. Most of the escapement Is to the upper Yaklma, but Naches escapement can reach over 50%. Up to 40% of the Naches escapement is to the American River. The American River run is thought to be genetically distinct from the upper Yakima run, and this has been verified previously electrophoreticaliy by WDF. Over two million spring chinook smolts and fry from a number of stocks have been released into the Yakima subbasin, but these are thought, based on their low return rates, to have had very little genetic impact. The extent of the genetic impacts from these releases, which were released mainly in the Yakima, to a much smaller extent in the Naches, and not at all in the American, is unknown.

Yakima subbasin spring chinook fry are characterized by extensive winter migrations. The significance and potential genetic basis of this behavior is unknown.

The YKPP intent for Yakima spring chinook is to supplement production 40% above the current level, to the point where hatchery returns comprise approximately 25% of returns to the basin. Exactly how the production will be distributed around the subbasin depends on how many genetically distinct substocks exist, but the American River population will not be supplemented (see section 4.4 above). Yakima spring chinook substock structure is therefore critical uncertainty in YKPP design. As part of YKPP prefacility research, WDF in 1989 sampled spring chinook spawners for electrophoretic and scale pattern analysis at seven sites throughout the upper Yakima, Naches, and American drainages. Repeat sampling and sampling at additional sites is scheduled for 1990. The electrophoretic data have been collected, and will be analyzed during the spring of 1990.

Currently the Yakima spring chinook are at depressed levels, but not obviously subject to any type of risk. Effective population size may be low in some substocks (Type 2a risk), but without substock information nothing definitive can be said. The most serious genetic threat imposed by YKPP is a Type 3 risk from interbreeding with the nonnative summer chinook to be introduced to the system, as the summer chinook may spawn in the lower reaches of the spring chinook spawning area (see section on Yakima summer chinook below). Any summer chinook releases will have to be very carefully monitored initially to assess this risk and prevent damage to the spring chinook. If several spring chinook substocks are identified and supplemented, Type 3 risk due to straying could also become a problem just among the spring chinook substocks, once supplementation begins and different release strategies are investigated. Type 1 and 2a risks could also arise as a result of mixed-stock harvests.

5.2 Yakima Fall Chinook

Fall chinook still exist in the Yakima subbasin. Spawning occurs in the lower river from Sunnyside to the Columbia, 70% of it below Prosser. Large introductions of upriver bright hatchery smolts have been made for several years. Lower Columbia smolts have also been released in the past. The little information available on hatchery returns suggests that most and perhaps nearly all the subbasin's fall chinook production is from natural spawning. Hatchery releases are considered to have a genetic impact, but locally adapted populations are thought to exist. Visibility in the lower river has hampered efforts to do much research on the stock. In the absence of other information, Yakima fall chinook are considered in terms of age structure and life history to be typical Hanford Reach fall chinook.

The current YKPP planned Yakima fail chinook production effort calls for an annual release of 3.6 million smolts, which it is hoped would result in hatchery returns comprising 35% of the run. Proportionate hatchery returns would be expected to decrease as natural production increases. Use of native broodstock is not considered essential, because of the presumed previous genetic impact of releases of hatchery fish from outside the subbasin. The preferred broodstock source is fish returning to the subbasin, but adults trapped at Bonneville will be used as necessary. In 1989 spawners were sampled for electrophoresis from Marion Drain and the mainstem Yakima River. Sampling will be repeated in 1990, and an additional site will be added. The electrophoretic data have been collected, and will be analyzed during the spring of 1990.

Given the tremendous in-river mortality rates experienced by released smolts, and the low return rates (3.9% in 1987), the basic YKPP planning premise that a substantial genetic impact by hatchery fish has already occurred is questionable. Thus, YKPP production could pose a substantial Type 3 risk to native Yakima fall chinook if nonnative broodstock is used. Use of Bonneville broodstock may pose substantial Type 3 risks to fall chinook stocks outside the subbasin as well. CWT spawning ground and hatchery recovery data compiled by WDF's Battleground lab indicate that Bonneville fish stray at substantial rates.

5.3 Yaklma Summer Chinook

Summer chinook are now considered extinct in the Yakima subbasin; no presumed summer chinook redds have been observed since 1970. The fish are thought to have utilized an area extending from just below Sunnyside upstream perhaps to Roza on the mainstem Yaklma and to the Tieton confluence on the Naches.

Current YKPP plans for summer chinook are to introduce fish from the Wenatchee River, and with a mix of natural spawning and hatchery supplementatlon achieve an adult run size of about 15,000 fish. Since water conditions in the subbasln are so poor for juvenile rearing, smolt outmlgration, and adult return of summer chinook, detailed planning of the program has been delayed.

Reintroduction of summer chinook to the Yakima subbasin poses no real genetic risk to the introduced stock, so long as the source of the introduced stock remains genetically healthy. If the introduced stock deteriorates genetically, it can be replaced. Ideally, however, the stock will be able to maintain itself without further introduction and become locally adapted. Because of the particularly inhospitable environment for summer-run fish, this stock may be substantially more subject to low effective size and even extinction (Type 2a and 1 risk, respectively) than the other Yakima chinook runs. Interbreeding with spring chinook is probable if these fish occupy the area historically used by Yakima summer chinook (Type 3 risk).

The greatest genetic rlsks associated with summer chinook production are Type 3 risks to other chinook runs. Summer chinook spawning areas will probably not overlap those of Yaklma fall chlnook, but will likely overlap those of spring chinook in both the mainstem Yaklma and the Naches rivers, creating opportunities for interbreeding. Introgression of genetic material from nonnative summer chlnook into Yakima spring chinook gene pools could seriously compromise the genetic integrity of these populations. This rlsk has been identified in the YKPP Experimental Design Plan, and a prefacility need recognized for development of hatchery procedures to avoid it. Given the emphasis placed by YKPP planners on spring chinook genetic resources, a successful summer chinook program poses a greater foreseeable genetic risk at this point than any other aspect of YKPP production. A Yakima summer chinook program may also put chinook populations outside the subbasin at Type 3 risk. Evidence of the importance of a genetic component in homing Is accumulating (McIsaac and Quinn 1989); fish released from sites far from their home basin may stray substantially.

5.4 Yakima Coho

Coho are now extinct In the Yaklma subbasln. Although development of the Yaklma subbasin probably played a dominant role in reducing their numbers, as it has for all Yakima salmonid runs, extinction was probably caused by heavy fishery exploitation. They are thought to have occurred throughout most of the basin, but to have been more numerous in the upper Yakima and Naches tributaries. Coho smoits have been released into the subbasin for many years, currently the Yakima Indian Natlon Is releasing 700,000 smolts per year produced by lower Columbia broodstocks. Some natural spawning form returning outplanted flsh has been observed.

The YKPP coho supplementation goal Is to produce a surplus of 40,000 adults to harvest at levels of 90% or more. In contrast to other YKPP supplementation programs, the emphasis Is on hatchery production, which is expected to provide virtually all the fish for harvest. If possible, however, adults returning to the hatchery will be used for broodstock to develop a locally adapted stock.

Genetic risks Inherent in Yaklma coho production are similar to those for summer chinook production. There are type 1 and 2a risks to the introduced stock, but no genetic loss is irretrievable so long as the source population remains healthy genetically. Most of the risks associated with coho production will be incurred by other stocks, not the Yakima coho. The intent is to have the coho In the streams only during outmigration and return to the hatchery, but interactions of coho smolts with juveniles of other species could pose Type 1 and 2a risks. Interactions with fall chinook have been identified as a potential risk in the YKPP Experimental Design Plan. Problems of this sort would be exacerbated by establishment of natural spawning in the subbasin, but harvests can probably be regulated to keep natural spawning at negligible levels. As in the case of summer chinook, straying may cause Type 3 risks in coho in other subbasins. There are no extant natural coho runs in this area of the Columbia basin, but excessive straying could interfere with efforts to reintroduce and naturalize stocks in other subbasins.

5.5 Yakima Sockeye

The Yakima subbasin was formerly a very large producer of sockeye, but sockeye are now extinct there, presumably due to loss of rearing areas caused by the damming of Keechelus, Kachess, and Cle Elum lakes. Recently the possible reintroduction of sockeye has become part of YKPP planning, but-the sockeye prefacility research is still in a very preliminary phase. YKPP sockeye could pose some risk to kokanee In subbasin lakes, both from ecological displacement (Type 1 and 2a risk) and interbreeding (Type 3 risk). Genetic Interactions between sockeye and kokanee are not well understood, but the two forms can interbreed. Similarly, kokanee could pose a Type 3 risk to the introduced sockeye. Introgression of native kokanee genes into the introduced sockeye population could promote naturalization, however.

5.6 Yakima Summer Steelhead

Currently the Yakima summer steelhead run numbers about 2,000 fish. Spawning is concentrated in Satus Creek, which accounts for about 50% of the subbasin's production, but also occurs from Roza to Wapato (40% of production) and in the Naches (10%). Spawning above Roza has been negligible due to passage problems at the dam, but Is expected to Increase with the recent correction of this situation. Over the last 30 years an average of 63,500 hatchery smolts have been released into the basin. Relatively few releases have been made above Roza, and in recent years stocking has been most intense in the Naches basin. No releases have been made into the Satus or Toppenish drainages. A variety of hatchery stocks have been used, but most released fish have been of the Skamania stock. In recent years Yakima steelhead collected at Prosser have been used exclusively for broodstock. Hatchery returns have accounted for as much as 20% of the return in the 1980's. The Washington Department of Wildlife annually stocks 35,000 catchable rainbow trout Into the Naches drainage (Jim Cummins, WDW, pers.comm.).

As currently planned, YKPP production will increase the Yakima summer steelhead run, exclusive of Satus Creek (which will be a refugium population), by 40%, to a subbasin total of about 7,000 fish. Native broodstock will be used. Sampling for electrophoretic substock identification was begun in 1989 by collection of smoits at Roza, Wapatox, Prosser, and in Dry Creek, a Satus Creek tributary. Sampling at most locations will be repeated this year, and additional sites will be added,

Current steelhead supplementation practices pose substantial genetic risks to Yaklma summer steelhead. Broodstock collection at Prosser insures that the released smoits are a genetic mix of fish from ail over the basin, and they are stocked over large areas of the basin. The long term consequence of this activity, will be a homogenization of genetic material throughout the stocked areas, a serious Type 3 problem. if these fish stray due to being released away from their natal basins, they may be moving into the unstocked, presumed genetically unimpacted drainages (Satus and Toppenish) as well. This mainstem broodstock collection also may be severely impacting the number of spawners in some streams, causing Type 1 and Type 2a risk, because there is no way of knowing where the spawners were originally bound.

Current rainbow trout stocking program also pose a potential Type 3 risk. There Is no general understanding of the extent to which rainbow and steelhead interbreed, but the fact that there is no dependable biochemical, meristic, or morphometric way to separate the two forms, suggests interbreeding is a definite possibility. interbreeding between the two forms is especially undesirable in this case because of a major genetic difference between rainbow/steelhead trout on the two sides of the Columbia divide. Yakima steelhead are “Inland” fish, whereas stock, genetically quite distinct from the hatchery rainbows, which are from a “coastal” stock.

YKPP productlon plans at this point pose no obvlous risk to Yakima summer steelhead. if several steelhead substocks are identified and supplemented, Type 3 risk due to straying could also become a problem just among the substocks, once supplementation begins and different release strategies are Investigated. Type 1 and 2a risks could also arise as a result of mixed-stock harvests.

5.7 Yakima Rainbow Trout (Nontarget)

Over the years, as steelhead have been virtually extirpated in the Yakima basin above Roza dam, a trophy ralnbow trout fishery has developed. A major concern of YKPP production planning is the impact of restored summer steelhead runs In this are on the rainbow trout fishery. The overall extent to whlch the rainbow trout have been impacted by hatchery stocking is unclear, but eiectrophoretic analysis indicated that mainstem fish have been more impacted than those in tributaries (Campton and Johnston 1985).

The YKPP potentially poses substantial displacement (Type 1 and 2a) and interbreeding (Type 3) risks to the rainbow trout. A major YKPP prefacility research effort is a study of the upper Yakima rainbow trout and their interactions with steelhead, both ecological and genetic. Once results from this study become available, a more detailed risk assessment will be possible.

5.8 Yakima Cutthroat Trout (Nontarget)

The distribution and abundance of cutthroat trout in the Yaklma subbasln is unknown. Currently WDW annually releases 20,000 westslope cutthroat into lakes in the headwaters of the Amerlcan River (Jim Cummins, WDW, pers. comm.). YKPP actlvltles potentially pose ecological displacement (Type 1 and 2a) risks to the cutthroat populations. Natural interbreeding between steelhead and cutthroat has been reported in the state (Campton and Utter 1985), so there is also the posslbiiity of Type 3 risk. Habitat preferences probably iimlt the opportunity for Interactions between the two species, so the risks are probably negligible.

5.9 Kllckltat Spring Chinook

Historically, a spring chinook run estimated at 1,000 to 5,000 existed in the Kiickitat Rlver. Productlvlty was limited by passage difficulties at Lyle Falls, two miles from the Coiumbla confluence. in 1952 passage over the fails was improved and a WDF hatchery became operational. Since then, several miiiion spring chinook fry, parr, and yearlings have been released on- and off-station into the subbasin. Most releases have been of Kiickitat chinook, but the Carson, Cowiitz, and Wiiiamette stocks have also been used. The Carson stock has probably had the largest genetic impact, accounting for 15% of the 1977 releases and 91% of the 1987 releases. The extent of natural spawning in the basin is unclear. Some natural spawning has been observed upstream of the hatchery, but opinions are dlvided as to whether these spawners truly represent a remnant wild population, or are just hatchery strays, The general lack of knowledge concerning the distribution of spawners, either historlcally or at present, makes any discussion of substocks pure speculation.

YKPP production of spring chinook should reach a run size of 28,000-30,000 by year 10. Annual hatchery smoit production will be 3,000,000, quadruple the output of the current WDF hatchery. Hatchery fish are expected to comprise 60-70% of the run. Returning hatchery fish wlll be preferentially used as broodstock, but other hatchery stocks (Carson has been suggested) wlll be used If necessary. Natural production is to be improved by new improvements for fish passage at Castiie Falls (river mile 62), which Is effectively the present upper boundary of spawning. Because of the presumed large genetic impact of introduced stocks, and present low levels of natural spawning, the genetic impact of YKPP production on natural reproducing fish is a low priority concern. However, genetic characterization of the hatchery and naturally spawning fish is considered an important prefacility informational need. In 1989 returning Kiickltat and Carson (released at Kiickitat) were sampled for eiectrophoresis. Resampiing Is planned for 1990, with sampling of natural spawners to be added. Electrophoretic data from the 1989 sampling will be analyzed in the spring of 1990.

Obviously, the current genetic status of Kiickitat spring chinook is unclear. Any naturally spawning substocks still existing after so many years of hatchery operations may be sufficiently isolated from the hatchery stock that their situation is stable, but they are potentially subject to Type 1, 2a, and 3 risk. Overall, Type 3 risk is the most serious genetic problem the fish currently face, regardless of whether there are still naturally spawning stocks or there is only one primarily hatchery stock. The threat comes from the release of nonnative spring chinook from the hatchery. The Klickitat subbasin is zoogeographicaiiy a "coastal" drainage, and the spring chinook consequently are (or were) quite distinct from "inland" spring chinook. The Carson stock, which has been heavily used for Kiickitat releases in recent years, is an inland stock. Interbreeding between Carson and Klickitat chinook may thus be very damaging to what is left of the native Klkkitat gene pool. The Carson releases were ail marked, and the intent was to not use them in spawning operations, but it is not known how successful this control measure was, and there Is no way to control naturally spawning Carson fish. It should be recognized, that although it may have been genetkaliy Impacted by releases of other stocks, the hatchery stock may be the sole reservoir of the original genetic variability found In Klkkitat spring chinook.

Under YKPP operations the major risk apparent at this point, one which is prominent in the YKPP Experimental Design Plan, is Type 4, domestication selection. Aithough naturally spawned fish are Intended to be used as broodstock, the high hatchery demand for spawners may leave only hatchery-produced fish as natural spawners. If substantial Type 4 effects occur, they will buiid at a much higher rate than they would at lower levels of hatchery production. Also, a situation can easily be imagined where there are not enough naturally produced fish to meet broodstock demands; if hatchery fish were used to make up the shortfall, Type 4 effects would build faster. Additional genetk risks will be possible If multiple substocks occur, as In the case of Yakima spring chinook.

5.10 Klickitat Summer Steelhead

Little Is known about Kllckitat summer steelhead. Most available data come from sampling the commercial and sport catch. In recent years harvests have averaged about 4000 fish. The spawning distribution Is poorly known, being based primarily on three helicopter flights up the mainstem Kiickitat in 1988, but did indicate substantial spawning activity over several miles of river. With no information available on tributary spawning, there Is no Indication of distinct substocks. Hatchery smolts of the Skamania stock have been released since the 1960's. Recent releases have averaged 100,000 per year, ail released into the mainstem Klickltat below the WDF salmon hatchery (river mile 42). Hatchery returns accounted for 68% of the fish sampled in 1979-1981; no more recent quantitatlve data are available.

Under current YKPP plans, an adult run of 30,000 would be achieved by year 10. Hatchery production would supply 80% of the run, requiring an annual release of 850,000 smolts. Genetic risks to the naturally spawning population is a concern, and genetic comparisons of hatchery and wlld steelhead have been designated a prefacility informatlonal need. Sampling plans are being developed, but Kllckltat steelhead may not be sampled until 1991.

The current genetlc status of Klickltat steelhead is unclear. Any naturally spawning substocks still exlsting after so many years of hatchery operations may be sufficlently isolated from the hatchery stock that their situation is stable, but they are potentlally subject to Type 1, 2a, and 3 risk. Unlike the sprlng chinook situation, however, the amount of steelhead spawning activlty In the river suggests that a vlable naturally spawning population may still exist. In general the Type 3 risk from hatchery releases Is not as severe as in the case of chinook because the releases have all been Skamania steelhead, and this stock was created from Klickitat and Washougal broodstock. The released fish are then only partially nonnative. However, this is a relatively old stock, and may have undergone conslderable genetic drift and domestication selection in hatcheries. Type 3 risk may also be present from rainbow trout stocking by WDW. Current rainbow trout stocklng Is llmlted to the Little Kllckftat River (Jlm Cummlns, WDW, pers. comm.), so the potential impact would be expected to be greatest for steelhead substocks in that region of the drainage.

YKPP plans, in proposing to use returning Klickitat steelhead as broodstock, reduce Type 3 rlsk markedly over the current hatchery program. If multiple substocks are found, the levels of production intended may cause Type 1, 2a, from displacement and mixed-stock fisheries, and of course Type 3. The high levels of production planned may create Type 4 problems, as In the case of Kllckltat sprlng chinook. A final potential problem is interbreeding with the small wlnter steelhead populatlon In the rlver (see sectlon 5.11); given the vast differences In the populatlon slzes of summer and winter steelhead under YKPP production, this impact on summer steelhead is likely to be negligible.

5.11 Klickitat Winter Steelhead (Nontarget)

A winter steelhead run of perhaps a few hundred fish exists in the Klickitat subbasin. Very little information is available on these fish, but they probably spawn in the lower reaches of the drainage (Howell et al. 1985). This stock is not to be supplemented under the YKPP, but the genetic risks to the stock from summer steelhead supplementation are a concern to YKPP planners. Sampling for electrophoresis, data from which will be required to detect interbreeding with the summer steelhead, was begun in 1990.

Klickitat summer steelhead supplementation potentially poses major displacement (Type 1 and 2a) and interbreeding (Type 3) risks to the winter steelhead. The limited information available suggests the spawning areas used by winter steelhead are also used by summer steelhead. The vastly increased summer run could compete directly with the winter fish for spawning sites, The extent to which summer and winter steelhead interbreed in general is not known, but interbreeding has been observed in the Kalama River (Leider et al. 1984). If Klickitat winter and summer fish interbreed or will interbreed after summer fish occur in larger numbers, there is an obvious risk of swamping the winter stock genetically.

5.12 Klickitat Rainbow Trout

The distribution and abundance of rainbow trout in the Klickitat subbasin is unclear (John Weinheimer, WDW, pers. comm.). Unlike the Yakima situation, no clearly defined region of intenske rainbow trout fishing is apparent. YKPP activities potentially pose ecological displacement (Type 1 and 2a) and interbreeding (Type 3) risks to the rainbow trout. Too little information is available to assess the magnitude of these risks at present. Interaction studies, like those to be conducted on the Yakima, are needed.

5.13 Klickitat Cutthroat Trout

Coastal cutthroat trout are found in the Klickitat subbasin, but their distribution and abundance is unknown (John Weinheimer, WDW, pers. comm.). YKPP activities potentially pose ecological displacement (Type 1 and 2a) and interbreeding (Type 3) risks to the cutthroat. Habitat preferences probably limit the opportunity for interactions between the two species, so the risks are probably negligible.

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